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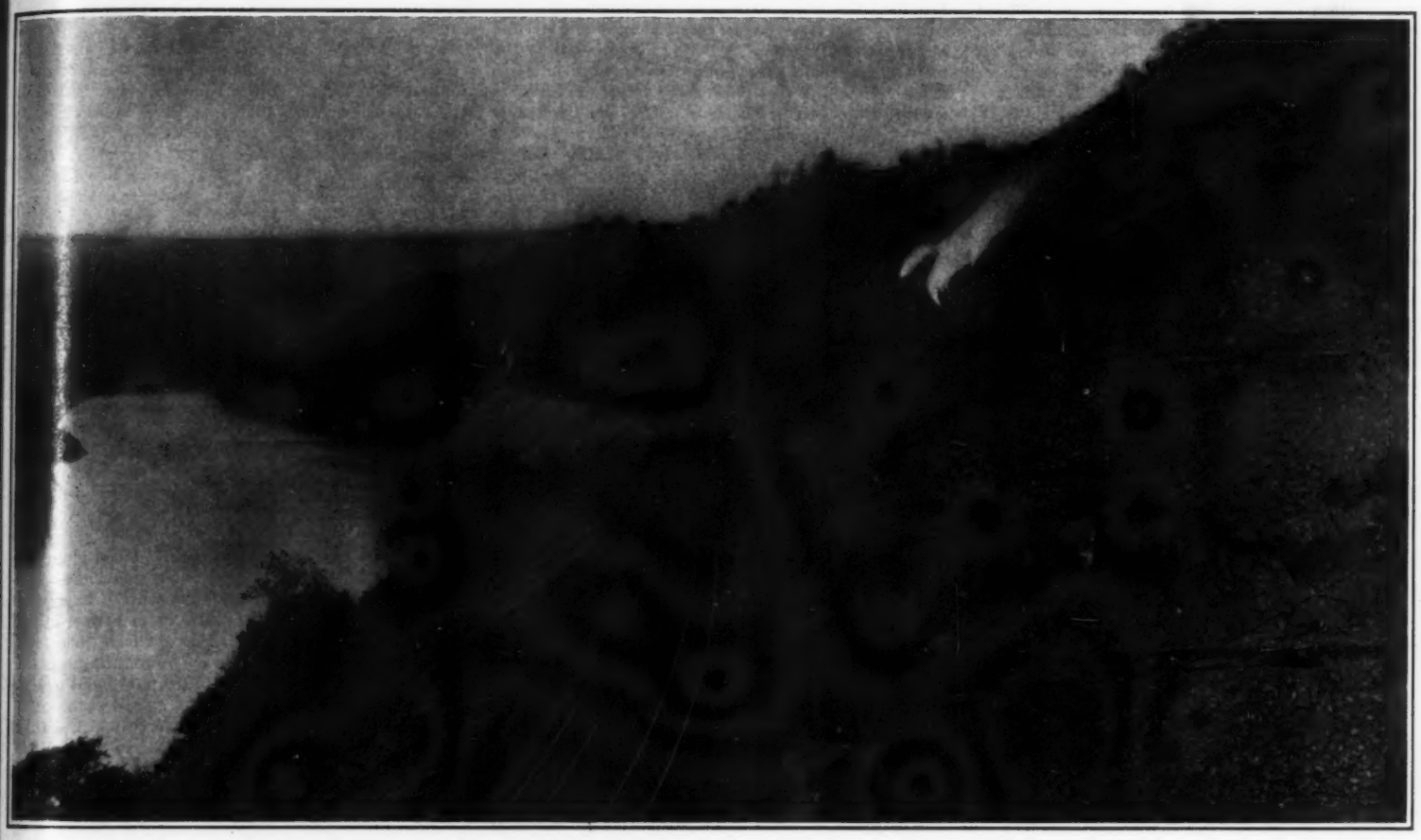


Forging the cut-off high above the level of the present roadbed. A point near Station No. 1592.

A bend in the line of the cut-off, westward from Station No. 1593.

THE MAGNOLIA CUT-OFF.—[See page 199.]

Heredity—III*

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2020, Page 179, September 19, 1914

I HAVE mentioned the condition of certain animals and plants which are what we call "polymorphic." Their populations consist of individuals of many types, though they breed freely together with perfect fertility. In cases of this kind which have been sufficiently investigated it has been found that these distinctions—sometimes very great and affecting most diverse features of organization—are due to the presence or absence of elements, or factors as we call them, which are treated in heredity as separate entities. These factors and their combinations produce the characteristics which we perceive. No individual can acquire a particular characteristic unless the requisite factors entered into the composition of that individual at fertilization, being received either from the father or from the mother or from both, and consequently no individual can pass on to his offspring positive characters which he does not himself possess. Rules of this kind have already been traced in operation in the human species; and though I admit that an assumption of some magnitude is involved when we extend the application of the same system to human characteristics in general, yet the assumption is one which I believe we are fully justified in making. With little hesitation we can now declare that the potentialities and aptitudes, physical as well as mental, sex, colors, powers of work or invention, liability to diseases, possible duration of life, and the other features by which the members of a mixed population differ from each other, are determined from the moment of fertilization; and by all that we know of heredity in the forms of life with which we can experiment we are compelled to believe that these qualities are in the main distributed on a factorial system. By changes in the outward conditions of life the expression of some of these powers and features may be excited or restrained. For the development of some an external opportunity is needed, and if that be withheld the character is never seen, any more than if the body be starved can the full height be attained; but such influences are superficial and do not alter the genetic constitution.

The factors which the individual receives from his parents and no others are those which he can transmit to his offspring; and if a factor was received from one parent only, not more than half the offspring, on an average, will inherit it. What is it that has so long prevented mankind from discovering such simple facts? Primarily the circumstance that as man must have *two* parents it is not possible quite easily to detect the contributions of each. The individual body is a *double* structure, whereas the germ-cells are *single*. Two germ-cells unite to produce each individual body, and the ingredients they respectively contribute interact in ways that leave the ultimate product a medley in which it is difficult to identify the several ingredients. When, however, their effects are conspicuous the task is by no means impossible. In part also even physiologists have been blinded by the survival of ancient and obscurantist conceptions of the nature of man by which they were discouraged from the application of any rigorous analysis. Medical literature still abounds with traces of these archaisms, and, indeed, it is only quite recently that prominent horse-breeders have come to see that the dam matters as much as the sire. For them, though vast pecuniary considerations were involved, the old "homunculus" theory was good enough. We were amazed at the notions of genetic physiology which Prof. Baldwin Spencer encountered in his wonderful researches among the natives of Central Australia; but in truth, if we reflect that these problems have engaged the attention of civilized man for ages, the fact that he, with all his powers of recording and deduction, failed to discover any part of the mendelian system is almost as amazing. The popular notion that any parents can have any kind of children within the racial limits is contrary to all experience, yet we have gravely entertained such ideas. As I have said elsewhere, the truth might have been found out at any period in the world's history if only pedigrees had been drawn the right way up. If, instead of exhibiting the successive pairs of progenitors who have contributed to the making of an ultimate individual, some one had had the idea of setting out the posterity of a single ancestor who possessed a marked feature such as the Habsburg lip, and showing the transmission of this feature along some of the descending branches and the permanent loss of the feature in collaterals, the essential truth that heredity can be expressed in terms of presence and absence must have at once become apparent. For the descendant is not, as he appears in the conventional pedigree, a sort of pool into which each tributary ancestral stream has poured something, but rather a conglomerate of ingredient-characters taken from his progenitors in such a way that some ingredients are represented and others are omitted.

Let me not, however, give the impression that the unraveling of such descents is easy. Even with fairly full details, which in the case of man are very rarely to be had, many complications occur, often preventing us from obtaining more than a rough general indication of the system of descent. The nature of these complications we partly understand from our experience of animals and plants which are amenable to breeding under careful restrictions, and we know that they are mostly referable to various effects of interaction between factors by which the presence of some is masked.

Necessarily the clearest evidence of regularity in the inheritance of human characteristics has been obtained in regard to the descent of marked abnormalities of structure and congenital diseases. Of the descent of ordinary distinctions such as are met with in the normal healthy population we know little for certain. Hurst's evidence, that two parents both with light-colored eyes—in the strict sense, meaning that no pigment is present on the front of the iris—do not have dark-eyed children, still stands almost alone in this respect. With regard to the inheritance of other color-characteristics some advance has been made, but everything points to the inference that the genetics of color and many other features in man will prove exceptionally complex. There are, however, plenty of indications of system comparable with those which we trace in various animals and plants, and we are assured that to extend and clarify such evidence is only a matter of careful analysis. For the present, in asserting almost any general rules for human descent, we do right to make large reservations for possible exceptions. It is tantalizing to have to wait, but of the ultimate result there can be no doubt.

I spoke of complications. Two of these are worth illustrating here, for probably both of them play a great part in human genetics. It was discovered by Nilsson-Ehle, in the course of experiments with certain wheats, that several factors having the same power may co-exist in the same individual. These cumulative factors do not necessarily produce a cumulative effect, for any one of them may suffice to give the full result. Just as the pure-bred tall pea with its two factors for tallness is no taller than the cross-bred with a single factor, so these wheats with three pairs of factors for red color are no redder than the ordinary reds of the same family. Similar observations have been made by East and others. In some cases, as in the Primulas studied by Gregory, the effect is cumulative. These results have been used with plausibility by Davenport and the American workers to elucidate the curious case of the mulatto. If the descent of color in the cross between the negro and the white man followed the simplest rule, the offspring of two first-cross mulattos would be, on an average, one black: two mulattos: one white, but this is notoriously not so. Evidence of some segregation is fairly clear, and the deficiency of real whites may perhaps be accounted for on the hypothesis of cumulative factors, though by the nature of the case strict proof is not to be had. But at present I own to a preference for regarding such examples as instances of imperfect segregation. The series of germ-cells produced by the cross-bred consists of some with no black, some with full black, and others with intermediate quantities of black. No statistical tests of the condition of the gametes in such cases exist, and it is likely that by choosing suitable crosses all sorts of conditions may be found, ranging from the simplest case of total segregation, in which there are only two forms of gametes, up to those in which there are all intermediates in various proportions. This at least is what general experience of hybrid products leads me to anticipate. Segregation is somehow effected by the rhythms of cell-division, if such an expression may be permitted. In some cases the whole factor is so easily separated that it is swept out at once; in others it is so intermixed that gametes of all degrees of purity may result. That is admittedly a crude metaphor, but as yet we cannot substitute a better. Be all this as it may, there are many signs that in human heredity phenomena of this kind are common, whether they indicate a multiplicity of cumulative factors or imperfections in segregation. Such phenomena, however, in no way detract from the essential truths that segregation occurs, and that the organism cannot pass on a factor which it has not itself received.

In human heredity we have found some examples, and I believe that we shall find many more, in which the descent of factors is limited by sex. The classical instances are those of color-blindness and hæmophilia. Both these conditions occur with much greater frequency in males than in females. Of color-blindness at least we know that the *sons* of the color-blind man do not inherit it (unless the mother is a transmitter) and do not transmit it to their children of either sex. Some, probably all, of the daughters of the color-blind father inherit the character, and though not themselves color-blind, they transmit it to some (probably, on an average, half) of their offspring of both sexes. For since these normal-sighted women have only received the color-blindness from one side of their parentage, only half their offspring, on an average, can inherit it. The sons who inherit the color-blindness will be color-blind, and the inheriting daughters become themselves again transmitters. Males with normal color-vision, whatever their own parentage, do not have color-blind descendants, unless they marry transmitting women. There are points still doubtful in the interpretation, but the critical fact is clear, that the germ-cells of the color-blind man are of two kinds: (i) those which do not carry on the affection and are destined to take part in the formation of sons; and (ii) those which do carry on the color-blindness and are destined to form daughters. There is evidence that the ova also are similarly predestined to form one or other of the sexes, but to discuss the whole question of sex-determination is beyond my present scope. The descent of these sex-limited affections nevertheless calls for mention here, because it is an admirable illustration of factorial predestination. It moreover exemplifies that *parental polarity* of the zygote to which I alluded in my first address, a phenomenon which we suspect to be at the bottom of various anomalies of heredity, and suggests that there may be truth in the popular notion that in some respects sons resemble their mothers and daughters their fathers.

As to the descent of hereditary diseases and malformations, however, we have abundant data for deciding that many are transmitted as dominants and a few as recessives. The most remarkable collection of these data is to be found in family histories of disease of the eye. Neurology and dermatology have also contributed many very instructive pedigrees. In great measure the ophthalmological material was collected by Edward Nettleship, for whose death we so lately grieved. After retiring from practice as an oculist he devoted several years to this most laborious task. He was not content with hearsay evidence, but traveled incessantly, personally examining all accessible members of the families concerned, working in such a way that his pedigrees are models of orderly observation and recording. His zeal stimulated many younger men to take part in the work, and it will now go on, with the result that the systems of descent of all the common hereditary diseases of the eye will soon be known with approximate accuracy.

Give a little imagination to considering the chief deduction from this work. Technical details apart, and granting that we cannot wholly interpret the numerical results, sometimes noticeably more and some times fewer descendants of these patients being affected than mendelian formulæ would indicate, the expectation is that in the case of many diseases of the eye a large proportion of the children, grandchildren, and remoter descendants of the patients will be affected with the disease. Sometimes it is only defective sight that is transmitted; in other cases it is blindness, either from birth or coming on at some later age. The most striking example perhaps is that of a form of night-blindness still prevalent in a district near Montpellier, which has affected at least 130 persons, all descending from a sin-

* An address delivered at Sydney, Australia, by Prof. William Bateson, M.A., F.R.S., President, before the British Association for the Advancement of Science.

gle affected individual[1] who came into the country in the seventeenth century. The transmission is in every case through an affected parent, and no normal has been known to pass on the condition. Such an example well serves to illustrate the fixity of the rules of descent. Similar instances might be recited relating to a great variety of other conditions, some trivial, others grave.

At various times it has been declared that men are born equal, and that the inequality is brought about by unequal opportunities. Acquaintance with the pedigrees of disease soon shows the fatuity of such fancies. The same conclusion, we may be sure, would result from the true representation of the descent of any human faculty. Never since Galton's publications can the matter have been in any doubt. At the time he began to study family histories even the broad significance of heredity was frequently denied, and resemblances to parents or ancestors were looked on as interesting curiosities. Inveighing against hereditary political institutions, Tom Paine remarks that the idea is as absurd as that of an "hereditary wise man," or an "hereditary mathematician," and to this day I suppose many people are not aware that he is saying anything more than commonly foolish. We, on the contrary, would feel it something of a puzzle if two parents, both mathematically gifted, had any children *not* mathematicians. Galton first demonstrated the overwhelming importance of these considerations, and had he not been misled, partly by the theory of pangenesis, but more by his mathematical instincts and training, which prompted him to apply statistical treatment rather than qualitative analysis, he might, not improbably, have discovered the essential facts of mendelism.

It happens rarely that science has anything to offer to the common stock of ideas at once so comprehensive and so simple that the courses of our thoughts are changed. Contributions to the material progress of mankind are comparatively frequent. They result at once in application. Transit is quickened; communication is made easier; the food-supply is increased and population multiplied. By direct application to the breeding of animals and plants such results must even flow from Mendel's work. But I imagine the greatest practical change likely to ensue from modern genetic discovery will be a quickening of interest in the true nature of man and in the biology of races. I have spoken cautiously as to the evidence for the operation of any simple mendelian system in the descent of human faculty; yet the certainty that systems which differ from the simpler schemes only in degree of complexity are at work in the distribution of characters among the human population cannot fail to influence our conceptions of life and of ethics, leading perhaps ultimately to modification of social usage. That change cannot but be in the main one of simplification. The eighteenth century made great pretense of a return to nature, but it did not occur to those philosophers first to inquire what nature is; and perhaps not even the patristic writings contain fantasies much further from physiological truth than those which the rationalists of the "encyclopædia" adopted as the basis of their social schemes. For men are so far from being born equal or similar that to the naturalist they stand as the very type of a polymorphic species. Even most of our local races consist of many distinct strains and individual types. From the population of any ordinary English town as many distinct human breeds could in a few generations be isolated as there are now breeds of dogs, and indeed such a population in its present state is much what the dogs of Europe would be in ten years' time but for the interference of the fanciers. Even as at present constituted, owing to the isolating effects of instinct, fashion, occupation, and social class, many incipient strains already exist.

In one respect civilized man differs from all other species of animal or plant in that, having prodigious and ever-increasing power over nature, he invokes these powers for the preservation and maintenance of many of the inferior and all the defective members of his species. The inferior freely multiply, and the defective, if their defects be not so grave as to lead to their detention in prisons or asylums, multiply also without restraint. Heredity being strict in its action, the consequences are in civilized countries much what they would be in the kennels of the dog-breeder who continued to preserve all his puppies, good and bad: the proportion of defectives increases. The increase is so considerable that outside every great city there is a smaller town inhabited by defectives and those who wait on them. Round London we have a ring of such towns with some 30,000 inhabitants, of whom about 28,000 are defective, largely, though of course by no means entirely, bred from previous generations of defectives. Now, it is not for us to consider practical measures. As men of science we observe natural events and deduce conclusions from them. I may perhaps be allowed to say that the remedies proposed in America, in so far as they aim at the eugenic regulation of marriage on a comprehensive scale, strike me as devised without regard to the needs either of individuals or of a modern State. Undoubtedly if they decide to breed their population of one uniform puritan grey, they can do it in a few generations; but I doubt if timid respectability will make a nation happy, and I am sure that qualities of a different sort are needed if it is to compete with more vigorous and more varied communities. Everyone must have a preliminary sympathy with the aims of eugenists both abroad and at home. Their efforts at the least are doing something to discover and spread truth as to the physiological structure of society. The spirit of such organizations, however, almost of necessity suffers from a bias toward the accepted and the ordinary, and if they had power it would go hard with many ingredients of society that could be ill-spared. I notice an ominous passage in which even Galton, the founder of eugenics, feeling perhaps some twinge of his Quaker ancestry, remarks that "as the Bohemianism in the nature of our race is destined to perish, the sooner it goes, the happier for mankind." It is not the eugenists who will give us what Plato has called divine releases from the common ways. If some fancier with the catholicity of Shakespeare would take us in hand, well and good; but I would not trust even Shakespeare's meeting as a committee. Let us remember that Beethoven's father was an habitual drunkard and that his mother died of consumption. From the genealogy of the patriarchs also we learn—what may very well be the truth—that the fathers of such as dwell in tents, and of all such as handle the harp or organ, and the instructor of every artificer in brass and iron—the founders, that is to say, of the arts and the sciences—came in direct descent from Cain, and not in the posterity of the irreproachable Seth, who is to us, as he probably was also in the narrow circle of his own contemporaries, what naturalists call a *nomen nudum*.

Genetic research will make it possible for a nation to elect by what sort of beings it will be represented not very many generations hence, much as a farmer can decide whether his byres shall be full of shorthorns or herefords. It will be very surprising indeed if some nation does not make trial of this new power. They may make awful mistakes, but I think they will try.

Whether we like it or not, extraordinary and far-reaching changes in public opinion are coming to pass. Man is just beginning to know himself for what he is—a rather long-lived animal, with great powers of enjoyment if he does not deliberately forgo them. Hitherto superstition and mythical ideas of sin have predominantly controlled these powers. Mysticism will not die out: for those strange fancies knowledge is no cure: but their forms may change, and mysticism as a force for the suppression of joy is happily losing its hold on the modern world. As in the decay of earlier religions Ushabti dolls were substituted for human victims, so telepathy, necromancy, and other harmless toys take the place of eschatology and the inculcation of a ferocious moral code. Among the civilized races of Europe we are witnessing an emancipation from traditional control in thought, in art, and in conduct which is likely to have prolonged and wonderful influences. Returning to freer or, if you will, simpler conceptions of life and death, the coming generations are determined to get more out of this world than their forefathers did. Is it then to be supposed that when science puts into their hand means for the alleviation of suffering immeasurable, and for making this world a happier place, they will demur to using those powers? The intenser struggle between communities is only now beginning, and with the approaching exhaustion of that capital of energy stored in the earth before man began it must soon become still more fierce. In England some of our great grandchildren will see the end of the easily accessible coal, and, failing some miraculous discovery of available energy, a wholesale reduction in population. There are races who have shown themselves able at a word to throw off all tradition and take into their service every power that science has yet offered them. Can we expect that they, when they see how to rid themselves of the ever-increasing weight of a defective population, will hesitate? The time cannot be far distant when both individuals and communities will begin to think in terms of biological fact, and it behooves those who lead scientific thought carefully to consider whither action should lead. At present I ask you merely to observe the facts. The powers of science to preserve the defective are now enormous. Every year these powers increase. This course of action must reach a limit. To the deliberate intervention of civilization for the preservation of inferior strains there must sooner or later come an end, and before long nations will realize the responsibility they have assumed in multiplying these "cankers of a calm world and a long peace."

The definitely feeble-minded we may with propriety restrain, as we are beginning to do even in England, and we may safely prevent unions in which both parties are defective, for the evidence shows that as a rule such marriages, though often prolific, commonly produce no normal children at all. The union of such social vermin we should no more permit than we would allow parasites to breed on our own bodies. Further than that in restraint of marriage we ought not to go, at least not yet. Something too may be done by a reform of medical ethics. Medical students are taught that it is their duty to prolong life at whatever cost in suffering. This may have been right when diagnosis was uncertain and interference usually of small effect; but deliberately to interfere now for the preservation of an infant so gravely diseased that it can never be happy or come to any good is very like wanton cruelty. In private few men defend such interference. Most who have seen these cases lingering on agree that the system is deplorable, but ask where can any line be drawn. The biologist would reply that in all ages such decisions have been made by civilized communities with fair success both in regard to crime and in the closely analogous case of lunacy. The real reason why these things are done is because the world collectively cherishes occult views of the nature of life, because the facts are realized by few, and because between the legal mind—to which society has become accustomed to defer—and the seeing eye, there is such physiological antithesis that hardly can they be combined in the same body. So soon as scientific knowledge becomes common property, views more reasonable and, I may add, more humane, are likely to prevail.

(To be continued)

[1] The first human descent proved to follow Mendelian rules was that of a serious malformation of the hand studied by Farabee in America. Drinkwater subsequently worked out pedigrees for the same malformation in England. After many attempts, he now tells me that he has succeeded in proving that the American family and one of his own had an abnormal ancestor in common, five generations ago.

Why Hens Stop Laying in Winter

It is a well established principle among agricultural economists that animals kept for their working abilities must not be allowed to get fat. Recent investigations show that excess of fat is even more injurious, and therefore expensive, in the case of animals kept for breeding purposes. For it has been proved indisputably that invasion by adipose tissue leads to the degeneration of the organs of reproduction.

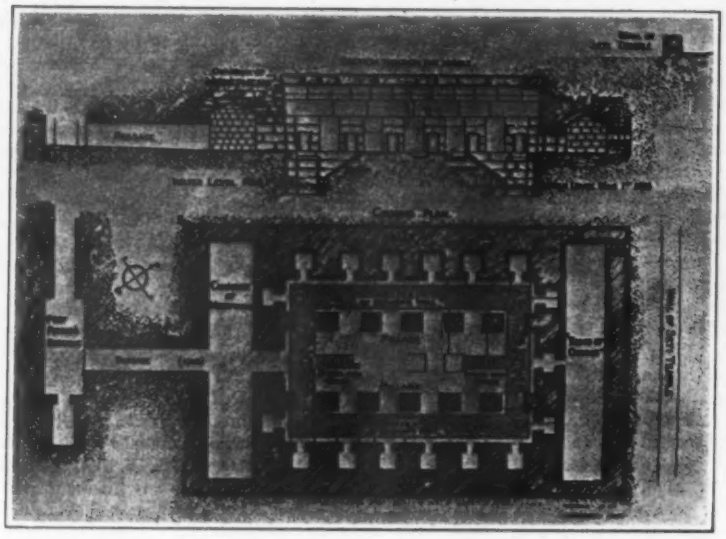
It is to this phenomenon, says the *Revue Scientifique*, that we must attribute the reduced egg yield of chickens at the end of winter. Though in perfect health and housed under the most sanitary conditions, hens are generally found at this time to be sluggish and laying so few eggs that the cost per egg is enormous.

This condition is the consequence of too great abundance of food during the winter, coupled with lack of exercise due to the narrow limits of the ordinary chicken-run. This is demonstrated by Mr. Brochemin in an article in *L'Acclimatation* which is quoted from by the *Revue Scientifique*. The balance of economy in the fowl's body is destroyed by a provision of grain which is in excess of the amount of energy it is called on to expend. And it is stated that if an autopsy be performed on such a victim of overfeeding there is found to be a general invasion of the tissues by fat, and the ovarian cluster has a limited development, proving that it is by no means in a state of full activity.

"In the liver the invasion may have proceeded so far that fat forms a constituent part of the active cells, whose functioning is thus forcibly interfered with. The same is true of the heart, which seems to have a special predilection for fat.

"The blood does not circulate so quickly, and, since the lungs have a sluggishness due to the same cause, there is not enough oxygen taken into the system to insure the combustion of the fat, and this is increasingly deposited in the tissues. According to a microscopic examination made by Mr. Dieulafoy, the muscular fibers are the seat of alterations more or less pronounced, whose final stage is the transformation of the fibers into a fatty cylinder."

While such extreme conditions are found only, as a rule, in fowl which have been specially fattened for food, the tendency of too liberal feeding is to cause a taking on of fat and cessation of laying. The obvious remedy is to give less food to hens which stop laying. But in practice a delicate balance must be observed, for hens which are prolific of eggs always have great appetites, and naturally need plenty of food for egg production. To avoid the horns of this dilemma, Mr. Brochemin advises a careful selection of rations, with strict limitation of starchy substances, such as maize, rice, and barley, while giving abundance of green food, such as cabbage, boiled clover, sorrel, etc. These act as stimulants of the liver, and thus are an excellent preventive of fat formation. Finally, he advises that the fowls be induced to take exercise, first by having an ample chicken-run, and by mixing their food with straw, etc., so that they will have to exercise when feeding.



Plan of the ruins at Abydos, showing form of the well, and location of tomb of Osiris.

Cyclopean monolithic pillars and architraves. The wall of the Seti Temple in the background.

The Cyclopean Mystery of Abydos*

The Recent Excavations of Strabo's Well and the "Tomb of Osiris"

By Edouard Naville

THE excavations made during the winter of 1913-14 at Abydos by the Egypt Exploration Fund under the direction of the present writer, assisted by Prof. Whittemore, from Boston, Mr. Wainwright, and Mr. Gibson, have given quite unexpected results. They have led to the discovery of a building which at present is unique in its kind, and which probably is one of the most ancient constructions preserved in Egypt: a great pool with porches and the tomb of Osiris. It is situate behind the western wall of the temple built by Seti I, which is the chief attraction of Abydos for travelers. It was entirely subterranean, at a depth of more than thirty feet below the temple, and nothing revealed its existence.

The work started from the western end of the construction, from a colossal door-lintel which had been discovered two years ago at the end of a passage covered with funerary inscriptions of King Menephtah, the Pharaoh of the Exodus. This lintel, of much more ancient date than the passage, is a doorway in a wall extending right and left, and of a thickness of more than twelve feet. On the southern side the corner had been reached. The top layers had been discovered of the inclosure wall built in magnificent masonry of hard red quartzite sandstone.

This year's work required a considerable number of workers. It was begun with 450; at the end there were 630, four fifths of whom were boys carrying baskets. The sides of the building had to be traced, and tons of rubbish and loose sand had to be removed from the middle: at the end of eleven weeks the whole structure had been laid bare.

It consists of a rectangle, the inside of which is about a hundred feet long and sixty wide. The two long sides are north and south; east is the side of the temple of Seti; west the doorway with the lintel, 15 feet long, which had been discovered in 1912. The inclosure wall is 20 feet thick. It consists of two casings; the outer one is limestone rather roughly worked; the inner one is in beautiful masonry of red quartzite sandstone. The joints are very fine; there is only a very thin stratum of mortar which is hardly perceptible. Here and there the thick knob has been left which was used for moving the stones. The blocks are very large—a length of 15 feet high is by no means rare; and the whole structure has decidedly the character of the primitive constructions which in Greece are called cyclopean, and an Egyptian example of which is at Ghizeh, the so-called temple of the Sphinx.

This colossal character is still more striking in the inner part. It is divided into three naves or aisles of unequal size, the middle one being wider. These naves are separated by two colonnades of square monolithic pillars in granite about fifteen feet high and 8½ feet square. There are five of them in each colonnade. They supported architraves in proportion with them, their height being more than six feet. These architraves and the inclosure wall supported a ceiling, also of granite monoliths, which was not made of slabs, but of blocks, like the architraves, more than six feet thick. It has been calculated that one of the few of them remaining weighs more than thirty tons. Unfortunately, in one corner only has the ceiling been preserved. The whole building has been turned into a quarry, especially the inside, which was entirely granite. Pillars, architraves, ceiling, everything has been broken and split

Reconstructed drawing of the newly found ruins at Abydos, showing method of construction.

* Reproduced from the *Illustrated London News*.

with wedges, traces of which are seen everywhere, in order to make millstones of various sizes. Several of them, weighing seven or eight tons, have been left.

The side aisles only, about ten feet wide, had ceilings. It is doubtful whether the middle nave was roofed. It was, perhaps, only covered at the end over the entrance to the "tomb of Osiris." When the work reached the lower layers of the inclosure wall, a very extraordinary discovery was made. In this wall, all round the structure, are cells about six feet high and wide, all exactly alike, without any ornament or decoration. They had doors, probably made of wood, with a single leaf; one can see the holes where they turned. Such cells are not seen in any other Egyptian construction.

What was still more surprising is that they do not open on to a floor, but onto a narrow ledge which ran on both sides of the nave. There was no floor in those aisles; under the ledge, which is slightly projecting, the beautiful masonry goes on, and at a depth of twelve feet water was reached. It is at the level of the infiltration water in the cultivated land, though the structure is in the desert. This year the Nile is lower than it is known to have been for more than fifty years. Were the river at a normal height, the water would reach the ledge, which is below the cultivated land. Thus the two aisles and the two ends of the middle nave form a continuous rectangular pool, the sides of which are very fine masonry of large blocks. How much deeper the wall goes than the present level of the water, it is difficult to say; but it probably goes down for another twelve feet. The excavations of next year will reveal what there is at the bottom. It was not possible this year to go farther because of the great number of granite blocks thrown into the pool. They will have to be hauled out, for among them may be statues or fragments of them.

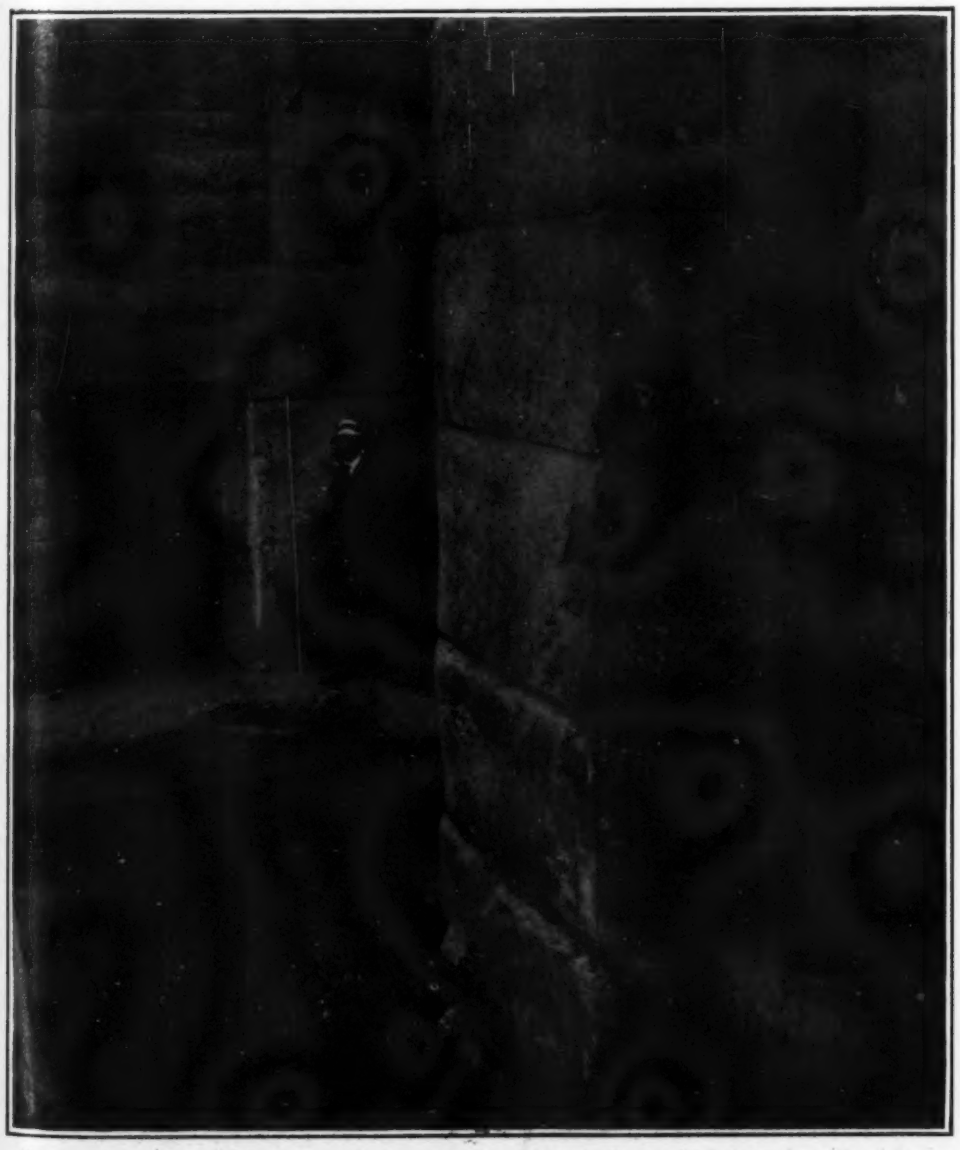
The middle nave is a block of masonry also made of enormous stones, which goes down as deep as the water, and on which rests the pillars of the colonnades. The floor is at the same level as that of the cells and of the ledge. This platform is an island: it could be reached only with a small boat or by a wooden bridge; there is water on the four sides. Even in front of the doorway there is only the ledge; there is no pathway of any kind leading to it. On both sides—east and west—there are two staircases leading from the platform to the water. The last step is about three feet above the present level of the water. In a normal year the two or three last steps would be covered.

The middle nave ends on the east side, the side of the temple of Seti, with a high wall on which are religious sculptures, the only ones in the whole building. They represent offerings made by Menephtah to Osiris and other gods; and the two important amulets which were generally worn or are found on the mummies. This showed that there was behind the wall something of a funerary character, the tomb of Osiris, perhaps. Osiris, although he was a god, was supposed to have been torn to pieces by his enemy, Set or Typhon, and his limbs had been scattered among the chief cities of Egypt. Abydos being the residence of the god, its share had been the head, which was buried in his tomb. That tomb was very famous, and various excavators have been searching for it for years. When the lower part of the end wall of the nave was cleared, there appeared the door of a cell quite similar to the other ones. The back wall of this cell had been broken through in order to make an opening, a door which had been blocked afterwards with stones. It gave access to a large subterranean chamber, wider than the whole construction, very well preserved, with a ceiling consisting of two slabs leaning against each other. On the ceiling and on the side walls are funerary representations like those of the tombs of the kings. It is evidently a tomb, and the sculptures show it to be what was regarded as the tomb of Osiris. The chamber was quite empty except for a heap of sand in one of the corners. When this had been removed, it was found that the sand came through a hole used by robbers. There was no sarcophagus nor object of any kind. It is not to be supposed that anything of that sort can be found in a construction used for centuries as a quarry.

The tomb of Osiris is of a later date than the pool with its cells. It dates from the time of Seti I, the grandfather of Menephtah, who probably made it when he built his temple. As for the pool, it is probably one of the most ancient constructions which have been preserved in Egypt. It is exactly in the style of the so-called temple of the Sphinx, which is a work of the Fourth Dynasty, and one of the characteristic features of which is the total absence of any inscription or ornament. But the pool is even more colossal. In the temple of the Sphinx the pillars are 4 feet square; here they are 8½. It is impossible, in spite of the havoc made, especially in the southern aisle, not to be struck by the majestic simplicity of the structure, chiefly in the corner where the ceiling has remained. Besides, this construction of a character quite unknown at present raises many questions which further excavations will, perhaps, solve. Was the pool in connection with the worship of Osiris? Did the sacred boat of the god float on the water? Since the boats of the gods are always towed with ropes, the ledge on both sides would be a very appropriate path for the priests who did it. What were the cells made for? Were they reproductions of those which the Book of the Dead describes as being in the celestial house of Osiris? Was the water supposed to have a curative effect; was it an Egyptian Pool of Bethesda?

As for the water itself, it must have been stored for some purpose. The enormous ceilings must have been made in order to prevent evaporation. Is it to be imagined that the old Egyptians made such an enormous construction merely for infiltration water? There is no

Uncovering the ruins at Abydos.



Huge masonry of one of the most ancient constructions known in Egypt. Showing ledge that surrounds Strobo's Well and the doorway to one of the cells. This view is in the southwest corner, indicated at B on the plan.

doubt that it is what is called Strabo's Well, which he describes as being below the temple, and like the Labyrinth at Hawara, but on smaller proportions, and with passages covered by big monoliths. Was there a canal coming from the Nile, as the Greek geographer says, or was the pool filled by the subterranean sheet of water which flows under the desert, the so-called underground Nile which is now being studied closely by the hydraulic engineers of Egypt? These are a few questions which arise from this discovery; and it is, therefore, most desirable that the generosity of the friends of the Egypt Exploration Fund may provide the society with the necessary financial means for completing this highly interesting and important work.

Mines in Naval Warfare*

Their Use in the Russo-Japanese Struggle

THE mine as an instrument of naval warfare is by no means so modern a contrivance as most people seem to imagine. Its first recorded appearance was at the siege of Antwerp in 1585, when the Dutch employed floating mines, exploded by means of clockwork connected to a matchlock arrangement, against the Spaniards with great success. Similar contrivances were employed by the English at the siege of La Rochelle in 1628, but with much less effect.

In the American Revolutionary war the submarine mine (as distinguished from floating contrivances of that nature) made its *début*. An American inventor named Bushnell made two attempts to destroy British war vessels by the agency of submerged kegs filled with gunpowder, and designed to explode on contact with other objects. These seem to have acted well, but partly owing to vigilance on the part of the British, and partly through the mines being set adrift at too great a distance from their object, no great damage was accomplished.

In the first few years of the nineteenth century the American inventor Fulton endeavored to find a market for a form of submarine mine with the French, and later with the British, then engaged in the Napoleonic struggle. Owing to their being too near the surface these mines did no harm to ships of the French fleet off Boulogne, against which they were tried in 1804; and though Fulton demonstrated the possibilities of his invention with more success on a brig off Walmer in the following year, he could not induce the British naval authorities to take it up as a permanent engine of war. He carried out further experiments in his own country in 1810, but afterward devoted his energies to other objects.

The Russians attempted to destroy ships of the British and French fleets by means of mechanical mines during the Crimean war, and actually succeeded in exploding one beneath H.M.S. "Merlin," but the charge used was so small that no serious damage was caused.

During the American civil war various forms of mines were used by the Confederates, and several Federal vessels were lost from this cause. As a result electrically controlled mines were adopted in this country in the early seventies; but it is only in comparatively recent years that any great use has been made of mechanical mines, notably in the Russo-Japanese war, when they played a most prominent part.

After the Japanese torpedo attack on the Russian fleet at Port Arthur on the night of February 7th-8th, 1904, the Russians realized the likelihood of the Japanese attempting an attack and landing troops (as they ultimately did) at Dalni, and to protect that port the minelayer "Yenesei" proceeded to lay a large number of mechanical mines in Talien Bay during the 9th, 10th, and 11th of February, 1904. On the third day, while attempting to destroy a mine which had broken loose from its anchorage and was floating on the surface, the "Yenesei" was very effectually hoisted by her own petard, and was lost with over ninety lives. The light cruiser "Boyarin" dispatched to investigate this occurrence, struck a mine when about to anchor, and subsequently sank, thus giving an early illustration of the dangers which this type of mine presents to those employing it.

Notwithstanding these discouragements, Rear Admiral Loschinski laid some eight hundred mines in Talien, Kerr, and Deep Bays during the second half of February, and though many were afterward found to have been laid at unsuitable depths, they were wisely considered too dangerous to interfere with.

In April the Japanese took a hand in the game, employing specially fitted merchantmen, destroyers, and torpedo boats for the work of laying mines. They devoted their energies to placing groups of mines in positions over which the Russian ships usually passed when maneuvering outside the harbor, and on April 13th the Russian fleet, coming out hurriedly to rescue one of their destroyers which was in danger or being cut off, came into this area. The flagship "Petropavlovsk," with Admiral Makaroff and the greater part of her crew of 700, was sunk; and soon afterward the "Pobeida," another battleship, was damaged on passing over another minefield, causing something approaching panic among the other Russian ships, who for the moment imagined themselves attacked by submarines.

On April 28th Japanese destroyers laid seventy-five mines in three groups outside of Vladivostok, as the result of which the Russians were deterred from using Ussuri Bay for some time afterward. A German steamer conveying coal to Vladivostok was sunk by one of these mines in June, and another in July. The Russians also lost a torpedo boat here by this cause in the latter month. In August one of their cruisers suffered damage from a mine while coming out from Vladivostok.

Meanwhile the Russians had not been idle. They laid two groups of mines to protect the entrance to the harbor at Port Arthur from attempts to block it, and several of the ships employed in the Japanese attack of May 3rd came to grief on these. A Japanese torpedo boat was destroyed while sweeping for mines in Kerr Bay, and on May 14th the Russian minelayer "Amur" (sister to the "Yenesei") succeeded in laying unobserved a number of mines about ten miles southeast of Lao-ti-Shan, outside territorial waters. This enterprise resulted more successfully than the Russians could have dared to hope, for the very next day the battleships "Hatsuse" and "Yashima" (the former flying the flag of Rear Admiral Nashiba) both struck mines and sank—the "Hatsuse" in a minute and a half, the "Yashima" after some hours spent in endeavoring to tow her to a place where she could be beached. Nor did this exhaust the list of Japanese misfortunes, for on May 14th the gunboat "Miyako" struck a mine in Kerr Bay and sank in twenty-three minutes, and on the 17th the destroyer "Akatsuki" met with a similar fate while on guard duty outside Port Arthur.

From this time onward both sides continued industriously to lay mines, at intervals desisting to sweep for those laid by their opponents. In June the "Amur" was disabled, thus depriving the Russians of their only remaining minelayer, and forcing them to rely on improvised vessels for this work. By this time they had organized a flotilla of steam hoppers for use as mine sweepers and also employed destroyers for that purpose.

During the Russian sortie from Port Arthur on June 23rd the battleship "Sevastopol" was severely damaged by a mine. By this time Talien Bay, after several weeks' work, had been practically cleared of mines by the Japanese, and their troops were able to disembark at Dalni, but stray mines still continued to give trouble. On July 5th the Japanese gunboat "Kaimon" was lost through striking one off Dalni, and on the 26th the cruiser "Chiyoda" was nearly sunk by a mine which exploded near her bow, and was with difficulty patched up enough to be taken back to dock in Japan. This was more than counterbalanced on the following day, when the "Bayan," the most enterprising of the larger Russian ships, had her foremost compartment flooded by the explosion of a mine under it when entering the harbor, and was obliged to dock for repairs, being thus unable to take part in the battle of August 10th. On the same day one of the steam hoppers belonging to the Russian mine-sweeping flotilla was sunk by a mine.

No further losses of capital ships took place on either side from mines during the war, probably owing to the greater precautions taken; but in the battle of August 10th, which resulted in the dispersal of part of the Russian fleet, and the retreat of the rest to harbor again, its movements were greatly hampered at the outset by the necessity for sweeping every yard of the water ahead of it before it could proceed, and its chances of getting through to Vladivostok were thus greatly lessened.

No more eloquent testimony of the part played by mines in the Russo-Japanese war could be sought than the appended list (based on the official history of the conflict) of losses sustained by both sides from this cause up to the fall of Port Arthur. If the Germans in the present war are employing mines as freely as is believed, the people of Great Britain must be prepared to face losses equally heavy with equanimity. The action of the "Konigin Luise" in laying mines outside territorial waters had its precedent in the Russo-Japanese war, but there were not a few criticisms of the action of both sides, at that time and subsequently, when merchant vessels continued to strike mines for quite a long time after peace had been concluded. It is true the Chinese were the chief sufferers, but some European vessels also fell victims to the casual ways of the combatants in strewing mines broadcast without any provision for their being rendered harmless if they broke loose. It is to be sincerely hoped that we shall not have a similar experience after the conclusion of the present struggle.

LIST OF RUSSIAN SHIPS LOST BY MINES, 1904-5.

"Yenesei" (armed minelayer), by own mines, February 11th, 1904.

"Boyarin" (light cruiser), by Russian mine, February 14th, 1904.

"Petropavlovsk" (battleship), by Japanese mine, April 13th, 1904.

Torpedo-boat "No. 208," by Japanese mine, outside Vladivostok, July 17th, 1904.

"Gremyashchi" (armored gunboat), near Port Arthur, August 18th, 1904.

"Vuinoslivi" (destroyer), near Port Arthur, August 24th, 1904.

"Stroini" (destroyer), outside Port Arthur, November 13th, 1904.

LIST OF JAPANESE SHIPS LOST BY MINES, 1904-5.

Torpedo boat "No. 48," in Kerr Bay, May 12th, 1904.

"Miyako" (large gunboat), in Kerr Bay, May 14th, 1904.

"Hatsuse" (battleship), May 15th, 1904.

"Yashima" (battleship), May 15th, 1904.

"Akatsuki" (destroyer), May 17th, 1904.

"Kaimon" (large gunboat), outside Talien Bay, July 5th, 1904.

"Otagawa Maru" (improvised gunboat), August 8th, 1904.

"Hayatori" (destroyer), September 3rd, 1904.

"Heiyen" (armored gunboat), September 18th, 1904.

"Saiyen" (light cruiser), November 30th, 1904.

"Takasago" (light cruiser), December 12th, 1904.

* Reprinted from the *Naval and Military Record* of August 19th, 1914, London, England.

The Impurities of Coal Gas

A New Method of Extracting the Sulphur Present

ONE of the most interesting papers presented at the fifty-first annual meeting of the Institution of English Gas Engineers held in Liverpool from June 16th to 18th was read by Dr. Charles Carpenter of London, and dealt with a new method of removing the carbon-bisulphide (CS_2), one of the most troublesome impurities of coal gas. The sulphur that finds its way into the gas from the coal is present in one of two forms, either in combination with hydrogen as sulphureted hydrogen (H_2S), or in combination with carbon as carbon-bisulphide (CS_2). The former is easily removed from the gas by passing over hydrated ferric oxide, the latter can only be removed by first converting it into the form of sulphureted hydrogen, and by then absorbing this gas in ferric oxide in the usual manner.

The interest of this process for the general public lies in its relation to the weight of sulphur that is brought into their houses and homes with the gas used for illumination purposes (gas heating and gas cooking stoves are connected to chimneys, or ought to be), and to the harm that is done to delicate fabrics and decorations by the sulphuric acid, which is ultimately formed on its combustion. Assuming that only 20,000 cubic feet of gas are employed in an ordinary house for illuminating purposes during the six winter months, when good ventilation is not possible, and that this gas contains 24½ grains sulphur in each 100 cubic feet, three quarters of a pound of the latter element will be contained in this amount of gas, and on combustion will yield 3 pounds of sulphuric acid, or oil of vitriol. Dr. Carpenter has clearly recognized that so long as this charge of contamination and damage can be brought against gas, the rivalry of the electric light will be keen, and in some districts successful; and it is for the purpose of putting the gas companies and undertakings in a stronger position to meet this competition, that he has revived and developed a method of breaking down and removing the carbon-disulphide by catalytic action.

Many attempts have been made in the past to introduce into the gas-making industry, methods and apparatus for removing the carbon bisulphide by catalysis, and at the Portland (Oregon) Gas Works, Messrs. Hill and Papst are now operating a process which enables over 70 per cent of the sulphur to be removed. Carpenter's own work on the subject commenced in 1906, and was carried out in ignorance of the Portland results. The method used is based upon the conversion of the carbon-bisulphide into sulphureted hydrogen by heating the gas to a temperature of 400 deg. Cent., and by then passing it through tubes filled with fire-clay balls coated with metallic nickel in a finely divided state, and maintained at a temperature of 450 deg. Cent. At this temperature the finely divided metallic nickel acts as a catalytic agent, and brings about the following reaction, without itself undergoing any chemical change:

$$CS_2 + 2H_2 = 2H_2S + C$$

carbon-bisulphide + hydrogen = sulphureted hydrogen + carbon

The carbon remains as a deposit of soot on the fire-clay balls, and at stated intervals it is necessary to

pass air through the reduction tubes, in order to burn off this deposited carbon.

This method of converting carbon-bisulphide into sulphureted hydrogen was first suggested by Vernon Harcourt, the eminent English scientist, in 1870, but the practical difficulties in the application of the process to the gas-making industry were very great, and only Hill and Papst in America, and Carpenter in England, have been able to overcome these with any degree of success. Carpenter works his process at a lower temperature than the American one, and in this way avoids any depreciation of the illuminating or thermal properties of the gas. By preheating the gas to 400 deg. Cent. before permitting it to enter the reaction tubes containing the catalytic agent, he is enabled to reduce the time required for the reaction, and to increase its efficiency, while by use of a cheap nickel salt (the chloride) for impregnating the fireclay balls, he keeps down the capital outlay required for equipping a purifying plant capable of dealing with large volumes of gas. A plant with a capacity sufficient to deal with the whole of the production has already been erected at the Old Kent Road (London) and East Greenwich Works of the South Metropolitan Gas Company, and the following figures summarize the results obtained at these two works since the new purification plant was installed:

OLD KENT ROAD, LONDON.
January, 1913, to May 31st, 1914.

Total volume of gas treated, 2,335,776,000 cubic feet.
Sulphur, before treatment by new process, 39.74 grains per 100 cubic feet.
Sulphur, after treatment by new process, 8.33 grains per 100 cubic feet.
Percentage reduction of sulphur, 79.3 per cent.

EAST GREENWICH, LONDON.
April and May, 1914.

Total volume of gas treated, 483,888,000 cubic feet.
Sulphur, before treatment by new process, 35.07 grains per 100 cubic feet.
Sulphur, after treatment by new process, 7.82 grains per 100 cubic feet.
Percentage reduction, 77.7 per cent.

Thus, nearly three thousand millions of cubic feet of gas have been treated by the new purification process since January, 1913, with an average reduction of nearly 79 per cent, and at an average cost of only 0.299 pence (0.598 cent) per 1,000 cubic feet.

In conclusion, it may be stated that Dr. Carpenter is president of the South Metropolitan Gas Company, the company which shares with the Gas-Light & Coke Company, the duty of providing the seven millions and odd inhabitants of London and its suburbs, with gas. Dr. Carpenter controls works employing 8,000 persons, and it was his company which twenty-five years ago, under the wise guidance of Sir Charles Livesey, initiated the system of profit-sharing that has been adopted by all the larger gas undertakings of the United Kingdom. It is no doubt true that *at present*, the managers and engineers of gas undertakings are not convinced that the large amounts of sulphur present as an impurity in their gas, handicap them in their efforts to gain new customers, or to retain the old ones. But the South Metropolitan Gas Company with Dr. Carpenter at its head, has given a lead to the other gas companies of the United Kingdom and of America, which is worthy of imitation.

The competition of electricity with gas is keen and will increase, especially where the electricity supply people can point to the damage done by the sulphur contained in gas. The writer will not be in the least surprised, therefore, if twenty-five years hence, all gas works managers and engineers are as keen about "purification," and the necessity for reducing the sulphur and other impurities contained in their gas to the lowest practicable limits, as they are now on the hire and sale of stoves and fires, and on the increase of their heating and cooking load. It will then be Dr. Carpenter's turn to smile.

The South Magnetic Pole has not yet been definitely located, according to recent reports from Dr. Mawson's Australasian Antarctic expedition. Heretofore it has been assumed that Dr. David visited this pole in the course of Shackleton's expedition, in 1909, but according to Mawson's recent investigations the spot reached by David, although lying within the region in which the magnetic needle is at times vertical, is not the center of that region, which appears to be of much greater extent than was formerly supposed. Moreover, there appear to be several local poles around the principal pole. One of these is supposed to lie near a region visited by Mawson southeast of Adélie Land.

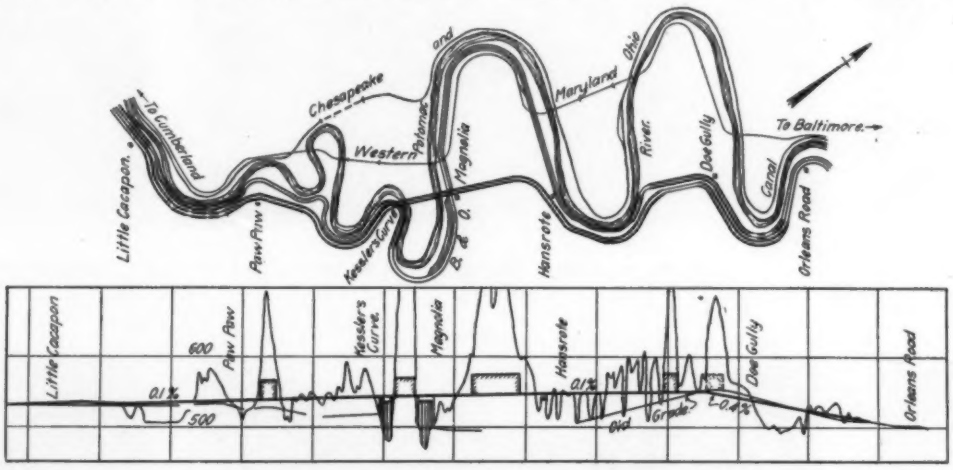
The Magnolia Cut-Off

An Improvement on the Baltimore & Ohio Railroad Costing Millions

By Harry C. Plummer

Up on the western watershed of the Blue Ridge Mountains, where the giant Mallet locomotives strain and tug at heavily laden freight trains, the Baltimore & Ohio Railroad has recently completed a $6,000,000 eleven-mile cut-off that ranks among the great engineering feats of American railroading.

The Magnolia cut-off improvement, between Orleans Road and Little Cacapon, W. Va., work upon which was started in May of last year (1913), accomplishes for the B. & O. two distinct economic advantages. It effects a saving of 5.8 miles in the length and 887 degrees of curvature of the eastbound tracks and does away with a sharp grade at Hansrote, which has required the use of pusher engines for eastbound traffic climbing the mountains at that point. Secondly, it completely equips the B. & O. as a three-track and four-track system east of Cumberland, Md., to Martinsburg, W. Va., and, in conjunction with extensive track additions on the mountain divisions, effected during the last three years, provides ample facilities to care for the almost indefinite future.



Map and profile of the Magnolia cut-off.

Factors of economic operation were directly responsible for the Magnolia cut-off improvement being undertaken by the Baltimore & Ohio Railroad. Embraced in a general economic study of its operation is the plan eventually to overcome the high operating costs in mountainous country by revising its line, reducing grades, eliminating curvature, and doing away with helper-engine service on that section of the line eastward from Cumberland, Md.

The plan contemplates a four-track system of 105 miles, from Cumberland to Brunswick, the point of intersection of the Cumberland and Baltimore divisions. In fact, the ultimate plan is to continue the four-track line to the seaboard at Baltimore, with the construction of third and fourth tracks from Brunswick to Washington Junction, Md., where two two-track lines converge toward Baltimore, one by way of Washington, the other through Frederick County. So, when it was determined to build the Magnolia improvement, the railroad began to "open the neck of the bottle."

The east end of the Cumberland division of the Baltimore & Ohio Railroad is known far and wide in railroad circles as the most congested stretch of railroad line in the United States. Two main lines, one from Chicago, the other from St. Louis, converge at Cumberland, with the bulk of their tonnage gathered from innumerable sub-main and branch lines. Most of this business is for seaboard movement to Washington, Baltimore, Philadelphia, New York, or New England. The question of keeping the trains moving with sufficient regularity to avoid blockades has long been one of moment and a problem calling for the most efficient operating methods.

The daily average train movement over the line is eighty-five trains of all classes, consisting of fast and local passenger trains, through, local and pick-up trains, and numerous work trains and contractors' equipment, and of this there is an average of seventy freight trains daily. Another factor in the operation of the line under conditions prevailing before the improvements were undertaken was the diversity of traffic, both with respect to volume and class of business, and many incidents occur which tend to bring on an abnormal movement of one grade or other of traffic.

While it has not been fully decided how the new line shall be used, it is generally believed that the two new tracks will be devoted to eastbound trains, and the old line turned over exclusively to westbound trains, this being the original idea when the line was surveyed.

So quietly has work progressed upon the cut-off that traffic upon the old tracks has not been at all interrupted and, by day and by night, the passengers on local and limited trains have been swept past the scene of the big improvement for the most part unmindful of the task the engineers have forged to a successful conclusion.

The greater part of the excavating has been done through solid rock. The slopes of the embankment, at river approaches, have been protected by concrete retaining walls, and the slopes along the hillsides terraced to obviate all danger from slides or falling rock.

Diverging from the eastbound side of the old three-track line west of Orleans Road, the cut-off line rises on a 4 per cent compensated grade for 4,500 feet to a point where it crosses the old line at grade. From that point it continues to rise on the same grade through the ridge at Doe Gully, where the tunnel of bygone days has been converted into an open cut.

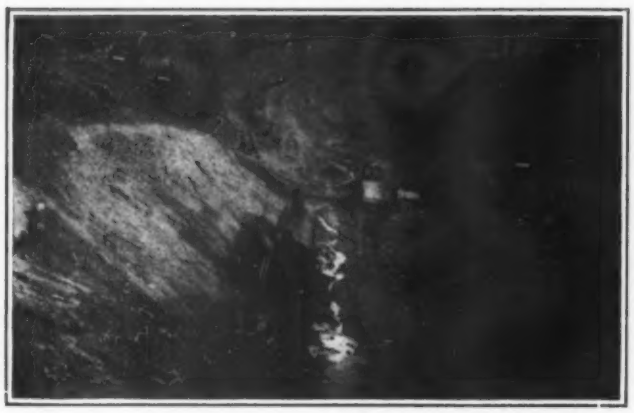
Briefly described, the improvement begins at Orleans Road. Four new tracks have been constructed, with gradients slightly less than those of the present tracks, through the summit at Doe Gully, removing the present tunnel and lowering the grade at the summit about ten feet. From Doe Gully the old track has been maintained for the westbound movement to Paw Paw. The new tracks have been constructed along the hillside above the older roadbed to a point just east of Hansrote, where they diverge to the left, passing through the ridge just east of Magnolia, crossing the present tracks overhead and the Potomac River at Magnolia, cut through the ridge on the west side of the river, and again crossing the present tracks at Kessler's Curve, overhead. The line then follows the hillside above the old tracks to a point just west of Paw Paw, where they again diverge to the left, passing through the ridge south of the old Paw Paw tunnel, by a short tunnel, and through the high ground just south of Paw Paw in an open cut, and coming out on the bank of the river just above the present tracks. From that point to Okonoko a four-track line has been constructed on a grade slightly higher than the present tracks, and above the elevation of the highest water heretofore known in the Potomac. As part of the automatic signal apparatus with which the line will be equipped, interlocking plants will be installed at Doe Gully, Magnolia, Little Cacapon, and Great Cacapon.

The improvement has cost approximately $6,000,000 and the operations have extended over a period of fourteen months.

Francis Lee Stuart, chief engineer of the Baltimore & Ohio Railroad, with headquarters at Baltimore, is in charge of the improvement.

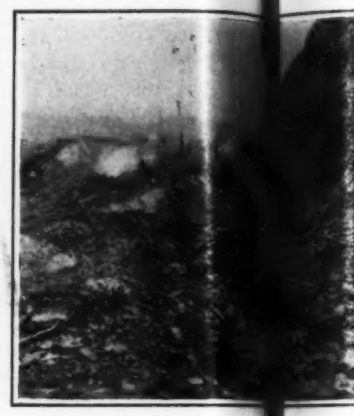
Concrete retaining wall on river embankment, viewed from present roadbed.

The conquest of mountain and hillside by the Baltimore & Ohio Railroad ... work on ... looking north ... tion No. 15



Easterly approach of cut to Paw Paw tunnel, on center line, near Station No. 1870.

Newly completed roadbed, showing shovel, traveler, and wall; below, the old roadbed on river bank.



The chaos of earth ... whence has ... symmetrical lin... Magnolia

Present tracks, eastward from Station No. 1840 (Section 6).

A cut through a bit of table-land, high above the river level.

Ready for the heavy traffic ... imposed up... from Station ... 36 and 1...

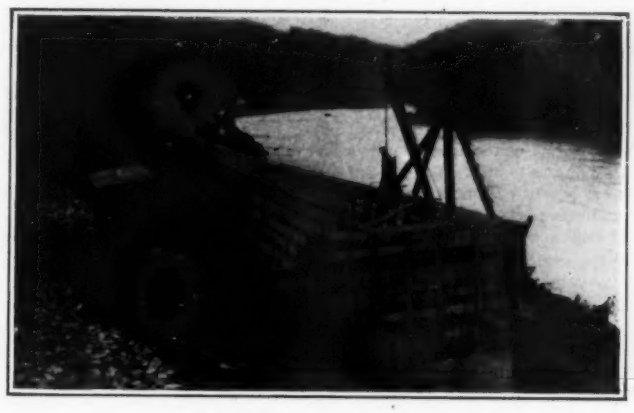
East approach to Stuart Tunnel. A battle against unyielding rock of the Blue Ridge.

Drilling and cutting the westerly approach to the Stuart Tunnel.

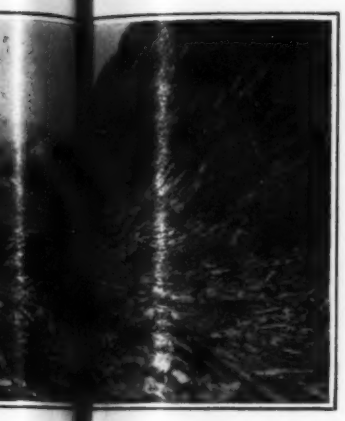
Shovel force penetrating ... rock on ... looking east ... of slope

THE MAGNOLIA CUT-OFF ON TH... ALTIM...

t work on the Magnolia cut-off; view of the north side of the Doe Gully Cut, tion No. 1543.

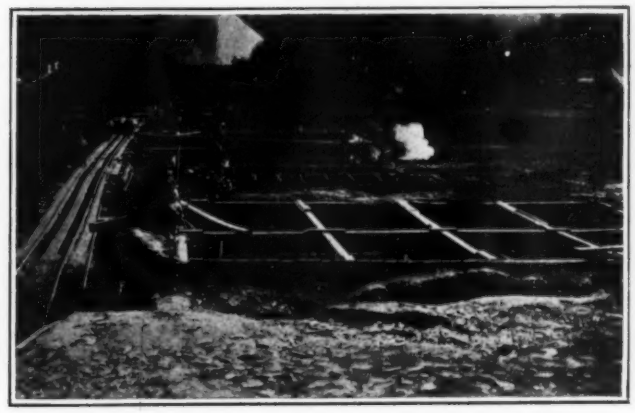


Another view of retaining wall built to guard against periodical rise of the Potomac.



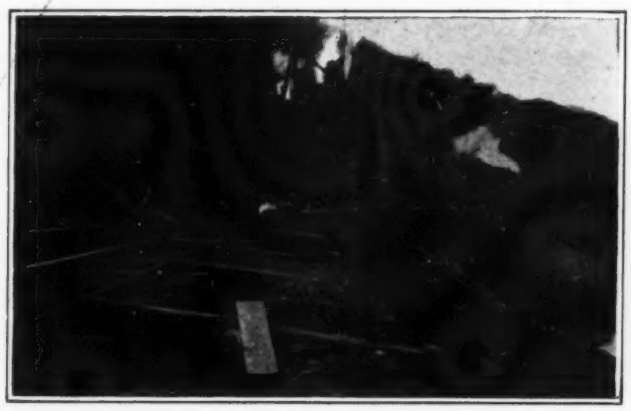
hence has sprung the Magnolia cut-off.

A comparatively open space on the Magnolia cut-off, south of Station No. 1921.

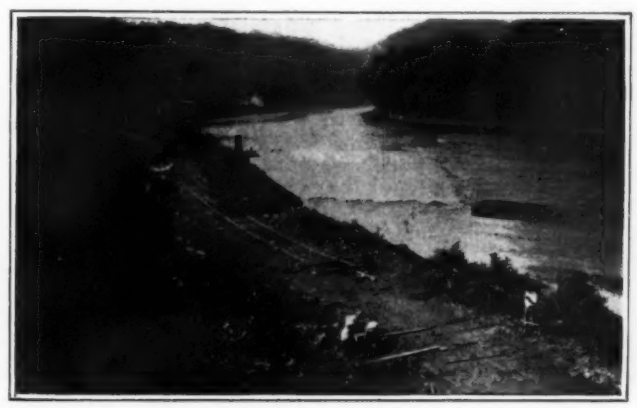


Bridging the winding Potomac at Magnolia for a short cut through the ridge seen opposite.

nposed upon it; westward 36 and 1955.



Traveler for erection of inner track wall at work on Section No. 6.



Laying the foundation for retaining wall west of Station No. 1933.

rock on Section No. 6 of slope.

Middle Bench, Doe Gully Cut, north side, viewed westward from Station No. 1544.

Top Bench, Doe Gully Cut; below, the present two-track line, Baltimore & Ohio Railroad.

The Baltic and Black Sea Canal Scheme*

An Improvement of Immense Importance to the Commerce of Central Russia

THE project for joining up the natural waterways between the Baltic and the Black Sea by the construction of artificial connecting channels has recently made an important advance. Although primarily intended for the development of commerce, the strategic value of such a connection between the great seas to the north and south of Russia will not be lost sight of, in view particularly of the demonstration of the value of the Kiel Canal in the German scheme of naval tactics. Thus an impetus will be given to the Russian project, which cannot be without great influence on the present study of the report of the Government Commission appointed to investigate the whole subject. This commission, which was appointed by the Duma and Senate four years ago, while intended to make a comprehensive survey of the whole scheme of internal navigation in Russia, was required to give primary consideration to the Baltic and Black Sea Canal scheme, and particularly the proposal to construct locks to circumvent the rapids on the great southern river, the Dnieper, which rapids at present check the complete utilization of this great natural waterway, piercing northward from the Black Sea into the very heart of European Russia. With its tributaries it affords navigable channels of nearly 4,000 miles, excepting for the obstructing rapids near the mouth. The canalization, for moderate-sized ships, of a connection between the river north and south of these rapids, now decided upon, must itself have a very important influence on the internal trade of Russia, apart altogether from the advance which would thereby be made toward the realization of the main project of water communication between the Baltic and the Black Sea.

A study of the map of Russia shows that the rivers of European Russia flow over great, broad plains between the two ranges of the Carpathian Mountains in the west and the Ural Mountains in the east, and that between the Baltic and the Black Sea two of the principal rivers are the Dnieper and the Dwina, the former, as we have said flowing into the Black Sea at Kherson and the latter into the Gulf of Livonia at Riga and thence into the Baltic Sea. These rivers, too are navigable for small craft for great distances into the interior, although in the case of the Dnieper there are rapids, owing to the great step-like formation, between the towns of Ekaterinoslav and Aleksandrovsk, some 200 miles from the mouth of the river, and in the case of the Dwina in the last 100 miles or so from the mouth to Jacobstad. As will presently be explained, there are projects for instituting electric-power generating-stations at the falls in both instances; but the necessity for navigation will be the primary consideration, the harnessing of waterfalls being subsidiary and contingent upon the requirements of shipping.

The sources of the two rivers at the "divide" are not far apart and the idea of connecting them by artificial waterways occurred to Peter the Great, who called in a Dutch expert to make a survey of possible routes through which canals could be constructed. Catherine II. supported this work of survey, but it was not until Russia had absorbed the Polish provinces that any material progress was made with the project. The canals then made, early in the last century, were intended for flooding purposes, and not really for shipping. Within the last twenty years, schemes for a deep canal without locks have been worked out, but the authorities considered the scheme impracticable from the financial point of view. Ultimately, as the result of private initiative, a company was formed and laid a scheme before the government for the construction of a waterway free from locks, and with a depth throughout the navigable channel of 14 feet. The main aim was to develop interior trade, and at the same time to afford a means of transit for merchandise passing through the Suez Canal to the countries on the shores of the Baltic and the Black Sea ports. It was proposed in this project to use large boats with motors, which would receive the goods at the terminals of the canal and deliver them either on the waterway or to large ocean-going vessels at the other end. At the same time the strategic value of the canal was recognized, but the scheme did not then meet with sufficient support. Now, however, owing to the more liberal constitution which has been introduced into Russia, and when more attention is being devoted to trade and commerce, there is greater prospect of the government recognizing the value of such an opening up of the natural resources and industrial potentialities of the interior of European Russia. Last year a large number of members of the Duma took the initiative for the actual completion of the Baltic-Black Sea Canal; they urged that exhaustive plans of the entire waterway, at the instance of the Public Works Department, should be ready at the beginning of 1914, and that from next year the Budget of this department should contain annual grants sufficient for the completion of this waterway in the course of five years.

The scheme which commends itself is that to which we have already referred—namely, the joining of the upper waters of the Dnieper and the Dwina, thus connecting Kherson, on the Black Sea, with Riga, on the Baltic. The length of such a waterway would be about 1,540 miles. The Dwina extends southward from the Riga port on the Baltic for a distance of 625 miles. Formerly there was a very extensive use of this waterway for barges, of which 21,000 annually traded to Riga with corn and other products from the upper reaches of the river. These barges had a carrying capacity of about 225 tons, and were carried down with the stream when the melting snow created a spate, but they were of little use for carrying supplies up country. Railway competition soon killed this method of transport, and now sailing vessels of from 10 tons to 80 tons or 90 tons capacity are used, and are navigated in both directions. Under these circumstances, the traffic has not increased greatly (except for the floating down of timber, to be made into rafts for shipment at Riga). In the upper reaches, however, for a distance of some 380 miles or so, steamers are in use, while for 940 miles, in tributaries and in navigable channels connected with the River Dwina, small steamers can be navigated. The river, from Bitebsk to Riga, a distance of about 370 miles, has a total fall of 348 feet, but the greater portion of this, as already indicated, is in the lower part of the river. The proposals for three hydro-electric power-stations—one of 4,000 horse-power and two of larger power—have been made in association with the canal parallel to the rapids; but, as has already been indicated, these will be subject to the main idea of making a canal through to the Black Sea. It may be said that from the upper Dwina a waterway debouches and communicates with St. Petersburg, but no survey has been made, although it is understood to offer no special difficulty in the way of development for navigation.

It is proposed to make a connection between the upper navigable part of the Dwina and the upper navigable part of the Dnieper, not by using the abandoned canals made 110 years ago, but by following the course of a tributary of the Dwina and one of the Dnieper near the watershed, which is some miles to the west of Smolensk. In the uplands there are two lakes which would be most useful for the feeding of the canals on each side of the water divide. The level of the water of the Dwina at Vitebsk is about 70 feet lower than that of the Dnieper at the most suitable point of junction. The distance between the rivers to be canalized is under 60 miles, and the proposal under consideration provides for three locks for the Dnieper and eight for the Dwina from the highest point. The cost of this canal, with wooden locks, is estimated at about 19 million roubles, and with stonework locks 6½ million roubles more.

The Dnieper, which is the third largest river in Europe, the Volga and Danube excelling it, has a length of nearly 1,350 miles, and in its course there is a population of something like 20,000,000. With the tributaries the total waterway is nearly 8,000 miles, of which about one half is navigable for small vessels. The products of the district are corn, timber, ore and coal, and undoubtedly there would be a great development of the natural and mineral wealth were the route to the sea improved. The obstacle, as we have mentioned, is the rapids between Ekaterinoslav and Aleksandrovsk. The largest vessels using the river below the rapids have a capacity of about 1,000 tons, and more than 300 steamers and 1,200 sailing craft are engaged in the service. Above the rapids the river, so far as it is to be used on the route, from sea to sea, is navigable for a distance of over 800 miles, and beyond this it is proposed to use the Beresina and the new canals already referred to. The Beresina is about 260 miles long and has a fall of about 90 feet, and it is proposed to canalize this portion with fourteen locks. Beyond this, as already indicated, there will be the canals connecting with the Dwina River, flowing into the Baltic. Although in the upper navigable part of the Dnieper there is a fall of 200 feet in 560 miles, it is thought that it would be practicable to make it navigable for larger vessels without locks, by means of regulation works and dredging. For 160 miles of the distance in the upper navigable region of the Dnieper, sandbanks are experienced, and regularization and dredging will have to be extensively done; for the next 270 miles the principal work would be the consolidation of the banks, and for the remaining130 miles or so to the rapids there is granite. Then come the rapids, the river breaking through a granite ridge. The fall in a length of 40 miles is 90 feet. Timber is floated through here, but the river is impossible to navigation, except at spates. Recently projects have been proposed for the harnessing of the water power, and a commission was appointed to investigate the subject. The plan now proposed is to build at the foot of the rapids a dam of granite, with Portland cement mortar. The canal for the passage of ships—parallel to the river, but independent of the flow to the turbines—is to be 90 feet wide at the bottom, with a minimum radius of 1,500 feet; the depth of water is to be about 7 feet, and the canal is to be constructed of brickwork where it does not pass through the natural rock. The locks are to be made in pairs alongside each other, and to accommodate two vessels of 180 feet long, with a tug-boat of 120 feet long. The cost of the work in connection with the navigation is calculated to be between 27 and 28 million roubles. The water-power part of the undertaking is designed for three power-stations with vertical reaction turbines; the aggregate capacity throughout the whole year is calculated to be 100,000 horse-power. The current, of 5,000 volts, will be transmitted to the distributing stations in the vicinity of Ekaterinoslav and as far as Nishni Novgorod. A French syndicate is understood to have just made an offer to the Russian government to undertake the construction of the locks and hydro-electric power-stations on the Dnieper.

The funds for the improvement of the Dnieper River from the mouth at Kherson to the falls were voted some four years ago, and the work is probably completed by this time. The actual commencement of the work, through the medium of the State, of an undertaking comparable with that of the Siberian railway, will, if decided upon by the Duma, be of great advantage to the commerce and industries of Russia. Mr. A. Pabst, harbor engineer in Riga, who has for years been deeply interested in the movement, and on whose recent lecture on the subject our article is based, is to be congratulated on the progress of the propaganda work.

* From *Engineering*, London.

Proofs of the Sun's Variability*

IT has been shown by experiments of the Smithsonian Astrophysical Observatory conducted simultaneously at Mount Wilson in California and Bassour in Algeria, in the years 1911 and 1912, that the values of the intensity of the solar radiation outside the atmosphere estimated by spectrobolometric observations at the two stations on the same days are, within the limits of error, identical. The measurements at the two stations agreed within an average deviation of about 1 per cent. It appeared, however, that the values of the solar constant of radiation obtained deviated over a range of nearly 10 per cent during the continuance of the expeditions. This deviation was observed at both stations, so that if high values were obtained in California, high values were obtained simultaneously in Algeria, and vice versa. Prof. Turner has computed from the observations the coefficient of correlation between the results at the two stations. He finds this coefficient to be 52 per cent plus or minus 7 per cent if all the observations are used. Rejecting three observations of extreme doubtfulness, the correlation coefficient rises to 60 per cent. This furnishes very strong evidence of the variability of the sun, which appears to be irregular in period and irregular in amplitude, but may range over a course of 5 per cent, or even more, within the lapse of a week.

Measurements of the solar constant of radiation have been conducted on Mount Wilson in California by the Smithsonian Astrophysical Observatory for about eight years, though, unfortunately, the observations have been confined to the months of summer and autumn, when the sky is favorable there for them. It is highly important that such work should be taken up at another station, or preferably at several other stations, where favorable conditions of the sky would be found in the other months of the year.

When the monthly mean values of the solar constant as obtained on Mount Wilson are compared with the sunspot numbers of Wolfer, it is found that increased sunspot numbers correspond with increased values of the solar radiation, and vice versa. Prof. Turner has computed the correlation coefficient for these two variables as depending upon fifty months of observations, and finds this coefficient to be 53 per cent plus or minus 7 per cent. Here also it is seen that a strong proof of the variability of the sun's radiation exists. It appears, therefore, that the sun, besides varying from day to day in the manner shown by the combined Algerian and Mount Wilson observations, also varies from year to year in connection with the march of the sunspot cycle.

* C. G. Abbot, Director Astrophysical Observatory, Smithsonian Institution.

In September, 1913, a tower telescope, forming the image of the sun by the use of mirrors without lenses, and yielding an image of about 9 inches in diameter, was made ready in connection with the station of the Smithsonian Astrophysical Observatory on Mount Wilson. The image of the sun is caused to fall upon the slit of a spectrobolometer, which slit for this purpose is only about three eighths of an inch in height. By stopping the clock of the telescope, the solar image drifts centrally across the slit of the spectrobolometer; owing to the diurnal rotation of the earth. There is thus produced, by automatic registering of the indications of the bolometer, a curve of distribution of intensity along the diameter of the sun's disk. This curve takes the form of a letter U. The length of the straight sides of the U may be taken as representing the intensity of the solar radiation at the edge of the sun's disk, and the height of the U to the center of the curve may be taken as representing the intensity of the radiation at the center of the disk. Thus a contrast of the intensity of radiation along the diameter of the sun is made manifest. Observations were made on nearly 50 days of the year 1913 with this apparatus, and on each day the distribution of intensity at seven different wave-lengths of the spectrum between 3,700 angstroms and 10,000 angstroms was determined by making two curves at each wave length. On the same days the solar constant of radiation was determined at Mount Wilson.

Work with a similar object, but done in different ways, has been carried on by Vogel, Pickering, Langley, Very, Schwarzschild and Villager, and Abbot and Fowle. It is found, by comparison of the distribution curves obtained at Mount Wilson in 1913 with others obtained by Abbot and Fowle in 1907, that a change of form of the distribution curve has occurred between these epochs.

The contrast of brightness between the center and edge of the sun in the year 1907 was greater than the contrast found in the year 1913. This is verified at all wave-lengths; but the change of contrast is greater for short wave-lengths than for longer ones.

It further appears, by comparison of results of one day with another in the year 1913, that a change of contrast is going on all the time, similar in irregularity of period and amplitude with the variation of the sun's total radiation which was found by comparison of Mount Wilson and Bassour observations. When the daily values of the solar constant of radiation obtained in 1913 are compared with the distribution of brightness along the sun's diameter, it is seen that a close correspondence of variation occurs between the two. This daily variation is of such a nature that when the solar constant values increase, the constant of brightness between the center and edge of the sun diminishes. The result is contrary to that which was indicated by a few observations of Abbot and Fowle in the year 1908. It is believed, on further examination, that the results of Abbot and Fowle in 1908 were made erroneous by certain defects in the measurements of the solar constant of radiation on two or three days. The new results come from nearly fifty days of observation, and are quite definite in showing the connections between the variation of the radiation of the sun and the variation of brightness along the sun's diameter.

It appears, however, that the correlation between solar constant values and contrast values between the years 1907 and 1913 is contrary in its sign to the correlation between these variables exhibited by the daily march of values for the year 1913. This may point to a greater complexity of the solar problem than was at first indicated by the results of Abbot and Fowle. It may be that the march of the sunspot period attends an influence in one direction, while the march of short-period fluctuations of the solar radiation from day to day attends a change of contrast in the other direction.

European Railways in War Time*

AMERICAN railway officers who have been inclined toward discouragement on account of the poor business conditions and the resulting effect on traffic and earnings which have prevailed in this country for several months, and which still exist, with considerable uncertainty as to the future, should be able to extract a grain of comfort from observation of the far worse plight of the roads in Europe. On the continent of Europe, railways in the territory affected by war operations have been required practically to suspend business except for the transportation of troops, and a great deal of their property has been destroyed or damaged, while the lines that are not directly affected by military operations are suffering from the loss of traffic because business is at a standstill. In Great Britain, where the railways are all owned by private companies, the government immediately on the declaration of war with Germany on August 4th, issued an order assuming control of the railways. For the time being, the railways practically cease to exist as individual commercial undertakings and are merely parts of a great national system.

The announcement of this step made by the British War office was as follows:

"An order in council has been made under section 16 of the Regulation of the Forces act of 1871, declaring that it is expedient that the government should have control over the railways in Great Britain. This control will be exercised through an executive committee composed of general managers of railways, which has been formed for some time, and has prepared plans with a view to facilitating the working of these provisions of the act.

"Although the railway facilities, for other than naval and military purposes, may for a time be somewhat restricted, the effect of the use of the powers under this act will be to co-ordinate the demands on the railways of the civil community with those necessary to meet the special requirements of the naval and military authorities.

"More normal conditions will in due course be restored, and it is hoped that the public will recognize the necessity for the special conditions, and will, in the general interest, accommodate themselves to the inconvenience involved."

The railway executive committee is composed of the general managers of ten of the leading railways in Great Britain, with the president of the Board of Trade as official chairman, and H. A. Walker, general manager of the London & South Western, as acting chairman. An American, H. W. Thornton, general manager of the Great Eastern, and formerly general superintendent of the Long Island, was not numbered among those chosen at first, but the committee had been in charge of affairs only two days when he was asked to become a temporary member, which he did.

This committee, through Mr. Walker, immediately issued a notice to the public explaining the situation, and stating that the control of the railways had been taken over by the government for the purpose of insuring that the locomotives, rolling stock and staff could be used as one complete unit in the best interests of the state, for the movement of troops, stores, and food supplies. "The necessity for this action must at once become apparent," the announcement said, "when it is realized that certain ports through which the bulk of our food supplies enters this country may be closed for the purpose of such food supplies and in that event the rolling stock, locomotives, etc., may have to be diverted to other lines for the purpose of serving other ports. The staff on each railway will remain under the same control as heretofore, and will receive their instructions through the same channels as in the past."

The announcement also stated that in order to give due effect to the instructions received from the War Office and the Admiralty for the movement of troops, etc., it might be necessary to discontinue, at short notice, a portion of the advertised service or to close certain of the lines against ordinary traffic, and that, under such circumstances, no responsibility could be accepted for any delay or loss that might arise.

The act under which control of the railways was taken by the government provides that when the Crown, by an order in council, declares that an emergency has arisen in which it is expedient for the public service that the government shall have control over the railroads or any of them, the secretary of state, by warrants, may empower any person or persons named to take possession of any railroad in the United Kingdom and of its plant or of any part thereof, or may take possession of the plant without taking possession of the railroad itself and use it for government service in such manner as the secretary of state may direct. Any such warrant is to remain in force for one week only, but may be renewed from week to week as long as, in the opinion of the secretary of state, the emergency continues. The act also provides for such full compensation for any loss or injury sustained by the railway companies by the exercise of this power as may be agreed upon between the secretary of state and the railways, and provides for arbitration in the case of difference; and that while the railways are in the hands of the government, all contracts for the operation and maintenance of the road shall be enforceable by or against the government.

The arrangement necessary for moving troops, horses and materials by rail for mobilization have been constantly under consideration by the military authorities, and the railways have naturally been regarded as an important factor in any mobilization scheme. There is a war railway council and a railway staff corps attached to the Royal Engineers, and there have been various meetings at the Board of Trade to discuss methods for obtaining the maximum efficiency of the railways. Immediately following the taking possession of the railways by the government, the London & South Western gave notice that, in consequence of the requirements in connection with the movement of the forces, it was not practicable to continue the whole of the passenger train service as advertised, and that it would be necessary to reduce and alter this service from August 5th until further notice. The notice stated that full particulars of the suspension and alteration would be issued, and the company also announced that it would be unable to guarantee the running or punctuality of trains, and could not be responsible for any delay, loss or damage which might occur in passenger train service. Similar notices of modified passenger train service were issued by other leading English and Irish railway companies, several of which announced that their ordinary passenger and goods train service would be subject to material alteration and discontinuance without further notice.

The publication of weekly traffic returns of the railways was also discontinued, as during the continuance of the war the railways will be operated almost as a single system, the government compensating the companies for any loss or injury in paying for the movement of troops and stores after the railways are restored to normal conditions. As the sums to be received from the government cannot be dealt with in weekly installments, the publication of these reports would, under the circumstances, be futile. With the business of the country disorganized on account of the obstacles to export and import traffic, the business of the railways would, of course, have been vitally affected even without the necessity for the use of their lines for military purposes.

With the practical cessation of European imports and exports and the general interruption of all kinds of business, the merchandise and general traffic has been heavily reduced, and the pleasure and ordinary passenger travel reduced to a minimum. Operating expenses will also naturally be affected by the rise in the prices of materials and in other ways. The declaration of dividends was postponed by several railways, pending the outcome of events.

The *Railway News*, of London, in its issue of August 8th, published an estimate that over 20,000 railway employees had left their employment in obedience to mobilization orders, their places being filled by promoting men of lower grades or by taking on new men for the less skilled occupations. The companies announced that so far as possible they would keep places open for the men who return to civil life when the war ends. At the time of the South African war, the railways not only made arrangements for keeping places open, but also for providing for those dependent upon the men killed or incapacitated during their military service. Similar arrangements are being made now.

The British railways have never yet been put to a complete test as to their ability in the matter of handling such a volume of traffic as would be necessitated in the transportation of an army to resist invasion, but they have often been called upon to handle large numbers of troops, horses and military equipment for maneuvers and royal reviews, frequently at times when their capacity was being subjected to a far greater strain by the handling of holiday passenger traffic.

The British railways are admirably adapted to the handling of troops in large numbers. Among the factors which are considered advantageous are the duplication of lines and the proximity of stations to each other. As the stations are rarely more than three or four miles apart, not all of the trains need go to the same station. Thus if 12 trains are required for the district served by stations *A*, *B* and *C*, the first, fourth, seventh and tenth trains could go to *A*, the second, fifth, eighth and eleventh to *B*, and the remainder to *C*. Should the trains run at 10 minute intervals, there would be half an hour to load or unload the first at *A* before the next train was due. Moreover, nearly all of the lines are double track and two trains may therefore, in emergency, be run in the same direction at the same time. Other advantages are found in the complete installation of block signals, telephones, speaking instruments and other signals.

As to the continental railways they are largely owned by the governments, and a great many lines have been built with reference to their possible use in war time; and naturally the transportation of military forces has been their first consideration. Germany's arrangements for mobilization by railway have been unusually complete. A war time-table, revised as occasion demanded, has always been in the possession of railway officers throughout the country, capable of being put into force at the shortest notice. All railways are administered by the military authorities in time of war, irrespective of whether the railways are state or company owned.

The Russian railways have a different gage from the other European lines and this difference has been maintained for strategic reasons. Short strategic lines built by Germany on the French and Belgian frontiers naturally have been of the greatest importance, and in addition most of the main lines are so located as to have the greatest efficiency for military purposes.

* *Railway Age Gazette.*

Plant Autographs and Their Revelations*

How Plants Are Compelled to Write the Story of Their Feelings and Sensations

In answering the question whether there is a fundamental unity in the response of plant and animal, we have first to find out whether sensitiveness is characteristic of only a few plants or whether all plants and every organ of every plant is sensitive. Then we have to devise apparatus by which visible or invisible reactions are detected and recorded. Having succeeded in this, we have next to survey the characteristic reactions in the animal, and observe whether phenomena corresponding to these may also be discovered in the plant.

Thus, when an animal is struck by a blow, it does not respond at once. A certain short interval elapses between the incidence of the blow and the beginning of the reply.

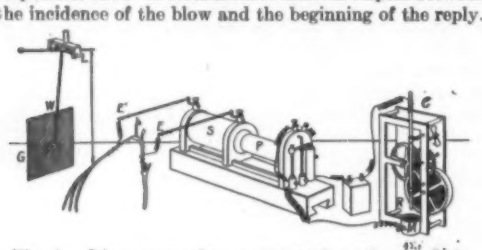


Fig. 1.—Diagrammatic representation of automatic plant recorder.

Petiole of Mimosa, attached by thread to one arm of level *L*; writing index *W* traces on smoked glass plate *G* the responsive fall and recovery of leaf. *P*, primary; *S*, secondary of induction coil. Exciting induction shock passes through the plant by electrodes *E*, *E'*. *C*, clockwork for regulating duration of tetanizing shock. Primary circuit of coil completed by plunging rod *R* dipping into cup of mercury, *M*.

This lost time is known as the latent period. In the plant is there any definite period which elapses between the incident blow and the responsive twitch? Does the latent period undergo any variation as in the animal, with external conditions? Is it possible to make the plant itself write down this excessively minute time-interval?

Next, is the plant excited by various irritants which also excite the animal? If so, at what rate does the excitatory impulse travel in the plant? In what favorable circumstances is this rate of transmission enhanced, and in what other circumstances is it retarded or arrested? Is it possible to make the plant itself record this rate and its variation? Is there any resemblance between the excitatory impulse in the plant and the nervous impulse in the animal?

The characteristic effects of various drugs are well known in the case of the animal. Is the plant similarly susceptible to their action? Will the effect of poison change with the dose? Is it possible to counteract the effect of one by means of another?

In the animal there are certain automatically pulsating tissues like the heart. Are there any such spontaneously beating tissues in the plant? If so, are the pulsations in the animal and the plant affected by external conditions in a similar manner? What is the real meaning of spontaneity?

Growth furnishes us with another example of automatism. The rate of growth in a plant is far below anything we can directly perceive. How, then, is this growth to be magnified so as to be rendered instantly measurable? What are the variations in this infinitesimal growth under external stimulus of light and shock of electric current? What changes are induced by giving or withholding food? What are the conditions which stimulate or retard growth?

And, lastly, when, by the blow of death, life itself is finally extinguished, will it be possible to detect the critical moment? And does the plant then exert itself to make one overwhelming reply, after which response ceases altogether?

* From a discourse delivered at the Royal Institution by Prof. J. C. Bose. Reproduced from *Nature*.

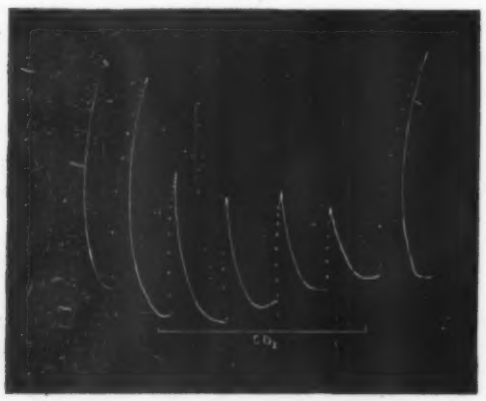


Fig. 4.—Effect of carbonic acid gas.

PLANT-SCRIPT.

The plant is acted upon by storm and sunshine, warmth of summer and frost of winter, drought and rain. What coercion do they exercise upon it? What subtle impress do they leave behind? These internal changes are entirely beyond our visual scrutiny. The possibility of these being revealed to us lies in the detection and record of the actual response of the organism to a questioning shock. By the invention of different types of recorders, I have succeeded in making the plant itself write an answering script to a testing stimulus. Thus the plant attached to the recording apparatus is automatically excited by a stimulus absolutely constant. In answer to this it makes its own responsive records, goes through its period of recovery and embarks on the same cycle over again, without assistance at any point from the observer (Fig. 1).

THE RESONANT RECORDER.

In obtaining the actual record of responsive movements in plants we encounter many serious difficulties. In the case of muscle-contraction, the pull exerted is considerable and the friction offered by the recording surface constitutes no essential difficulty. In the case of plants, however, the pull exerted by the motile organ is relatively feeble, and in the movement of the very small leaflets of *Desmodium gyrans* or the telegraph plant, for instance, a weight so small as four-hundredths of a gramme is enough to arrest the pulsation of the leaflets. Even in the leaf of Mimosa the friction offered is enough to introduce serious errors into the amplitude and time-relations of the curve. This error could not be removed as long as the writer remained in continuous contact with the writing surface. I was finally able to overcome the difficulty by making an intermittent, instead of a continuous contact. The possibility of this lay in rendering the writer tremulous, this being accomplished by an invention depending on the phenomenon of resonance. The principle of my resonant recorder depends on sympathetic vibration. If the strings of two violins are exactly tuned, then a note sounded on one will cause the other to vibrate in sympathy. We may likewise tune the vibrating writer *V*, with a reed *C* (Fig. 2). Suppose the reed and the writer are both tuned to vibrate a hundred times per second. When the reed is sounded, the writer will also begin to vibrate in sympathy. In consequence of this, the writer will no longer remain in continuous contact with the recording plate, but will deliver a succession of taps a hundred times in a second. The record will therefore consist of series of dots, the distance between one dot and the next representing one-hundredth part of a second. With other recorders it is possible to measure still shorter intervals. It will now be understood how, by the device of the resonant recorder, we not only get rid of the error due to friction, but make the record itself measure time as short as may be desired. The extraordinary delicacy of this instrument will be understood when by its means it is possible to record a time-interval as short as the thousandth part of the duration of a single beat of the heart. In finding the best mode of applying quantitative stimulus to the plant an interesting discovery was made about the extreme sensitiveness of certain plants to the stimulus of electric current. The most sensitive organ by which an electric current can be detected is our tongue. An average European, according to Laserstein, can perceive by his tongue a current as feeble as 6.4 micro-amperes—a microampere being one-millionth part of the unit of current. This value might be subject to certain variation, depending on racial characteristics. One might expect that the tongue of the Celt would be far more excitable than that of the stolid Anglo-Saxon. In any case, the superiority of man has to be established on foundations more secure than sensibility; for the plant Biophytum, I find, is eight times more sensitive to an electrical current than a human being. With regard to the stimulus of induction shock, Mimosa is ten times as sensitive.

Fig. 3.—Hourly record for twenty-four hours, exhibiting diurnal variation of excitability (spring specimen).

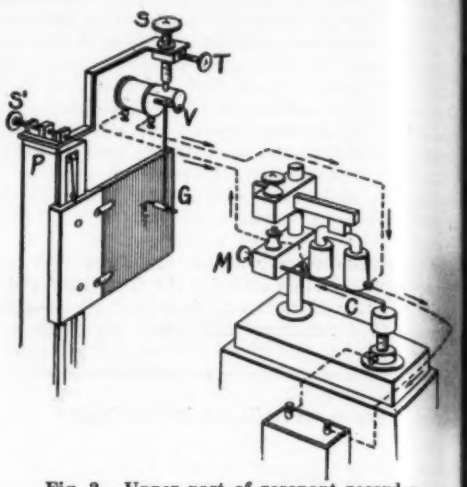


Fig. 2.—Upper part of resonant recorder.

Thread from clock (not shown) passes over pulley, *P*, letting down recording plate. *S*, screw for vertical adjustment; *T*, tangent screw for exact adjustment of plane of movement of recorder, parallel to writing surface; *V*, axis of writer supported perpendicularly at center of circular end of magnet; *C*, coercer; *M*, micrometer screw for adjustment of length of coercer.

THE SLEEP OF PLANTS.

In studying the effect of a given change in the external condition, an assumption has to be made that, during the time of experiment, there has been no spontaneous variation of excitability. Is the plant equally excitable throughout day and night? If not, is there any particular period at which the excitability remains uniform? Is there again a different time during which the plant loses its sensibility—going, as it were, to sleep? On these points no definite information has been available. The fanciful name of sleep is often given to the closure of leaflets of certain plants during darkness. These movements are brought about by variation of turgor, and have nothing whatever to do with true sleep; for similar closure of leaflets takes place under the precisely opposite condition of strong light.

In order to find out whether Mimosa exhibits diurnal variations of sensibility, I made it record its answer to uniform questioning shocks, repeated every hour of the day or night. The amplitude of the answering twitch gave a measure of the "wakefulness" of the plant during twenty-four hours. The results obtained were quite unexpected. The plant is found to keep up very late, and fall asleep only at the early hours of the morning. It makes up for its late hours by gradually waking up by noon (Fig. 3). It then remains in a condition of uniform sensibility all the afternoon. This period of uniformity is chosen for investigations on the effect of changed external conditions on excitability.

EFFECT OF AIR, FOOD, AND DRUGS.

The plant is intensely susceptible to the impurities present in the air. The vitiated air of the town has a very depressing effect. According to popular science, what is death to the animal is supposed to be life for the plant; for does it not flourish in the deadly atmosphere of carbonic acid gas? The record (Fig. 4) shows that, instead of flourishing, the plant gets suffocated just like a human being. Note the gasp of relief when fresh air is introduced. Only in the presence of sunlight is this effect

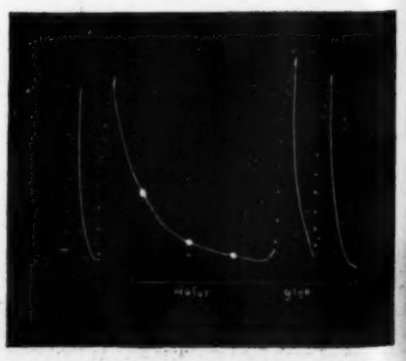


Fig. 5.—Abolition of motile excitability by excessive absorption of water, and subsequent restoration by withdrawal of excess.

modified by photosynthesis. In contrast to the effect of carbonic acid, ozone renders the plant highly excitable. Sulphureted hydrogen, even in small quantities, is fatal to the plant. Chloroform acts as a strong narcotic, inducing a rapid abolition of excitability. The ludicrously unsteady gait of the response of plants under alcohol could be effectively exploited in a temperance lecture! The record (Fig. 5) is in the nature of an anticlimax, where the plant has drunk (pure water!) not wisely but too well. The gorged plant is seen to have lost all power of movement. I was, however, able to restore the plant to normal condition by extracting the excess of liquid by application of glycerin.

It may be urged that the various reactions of irritability may hold good only in the case of the particular plant Mimosa, and that the majority of plants were quite insensitive. I have, however, been able to demonstrate in this very hall thirteen years ago, through my discovery of electric response in ordinary plants, that every plant and every organ of the plant is sensitive.[1] The difficult

Fig. 6.—Record showing the latent period of Mimosa. The recorder vibrates 200 times per second. The time-interval between successive dots is here 0.005 second.

problem of finding the time taken by the plant to perceive and respond to a blow was solved by the employment of my resonant recorder, in which the writer was tuned to vibrate two hundred times a second. The successive dots are thus at intervals of 1/200 part of a second apart. In a particular experiment there are 15.2 intervals between the application of stimulus, represented by a vertical line, and the initiation of response (Fig. 6). The latent period, therefore, in this case is 0.076 of a second. The reaction time of the plant becomes very sluggish under fatigue.

EXCITATORY IMPULSE IN MIMOSA.

I next take up the question of transmission of excitation in plants. It has hitherto been supposed in Mimosa the impulse caused by irritation is merely hydro-mechanical, and quite different from the nervous impulse in the animal. According to this hydro-mechanical theory, the application of mechanical stimulus is supposed to squeeze the tissue, in consequence of which the water forced out delivers a mechanical blow to the contractile organ of the plant. Such hydro-mechanical transmission is in no way affected by any physiological agencies as warmth or cold, or the application of various anæsthetics or poisons.

In strong contrast to this is the transmission of nervous impulse, which is a phenomenon of passage of protoplasmic disturbance from point to point. Here under favorable physiological conditions, such as warmth, excitatory impulse is transmitted with a quicker speed. There are certain agents again which paralyze the conducting tissue for the time being, causing a temporary arrest of the impulse. Such agents are known as anæsthetics. There may again be poisonous drugs which permanently abolish the conducting power. The nature of an impulse may thus be discriminated by several crucial tests. *The impulse must be physiological, or of a nervous character, if physiological changes affect the rate of conduction; absence of such effect, on the other hand, proves the mechanical character of the impulse.*

Of the various physiological tests, Pfeffer employed that of the narcotic drug. Chloroform applied on the surface of the stem of Mimosa failed to arrest the impulse. This result, at first sight, appears most convincing, and has been universally accepted as a disproof of the existence of nervous impulse in Mimosa. A little reflection will, however, show that under the particular conditions of the experiment, the conducting tissue in the interior could not have been affected by the external application of the narcotic, the task being, in fact, as difficult as narcotizing a nerve-trunk lying between muscles by the application of chloroform on the skin outside.

The question of nervous impulse in plants has thus to be attacked anew, and I have employed for this purpose twelve different methods. They all prove conclusively that the impulse in the plant is identical in character

Fig. 9.—Record of automatic pulsations in Desmodium gyrans.

[1] Bose: Friday evening discourse, May 10th, 1901.

with that in the animal. Of these I shall give a short account of two different modes of investigation. It is obvious that the transmitted impulse in Mimosa must be of an excitatory, or nervous character:

(1) If it can be shown that physiological changes induce appropriate variation in the velocity of transmission of the impulse.

(2) If the impulse in the plant can be arrested by different physiological blocks by which nervous impulse in the animal is arrested.

For the last two investigations the research resolves itself into the accurate measurement of the speed with which an impulse in the plant is transmitted, and the variation of that speed under changed conditions. A portion of the tissue at *C* may, for example, be subjected to the action of cold, or of a poisonous drug (Fig. 7). In order to find the speed of normal transmission, we apply an instantaneous stimulus, say, of an electric shock, at *B*, near the pulvinus. A short interval, the latent period, will elapse between the application of stimulus and the beginning of responsive movement. After the determination of the latent period, we apply stimulus once more at *A*, and observe the time which elapses between the application of stimulus and the response. The difference between the two periods gives us the time required for the excitation to travel from the point of application of stimulus at *A*, to the responding organ at *B;* hence we obtain the speed of impulse in the plant. The experiment is repeated once more, after the application of a given agent at *C*. If the speed undergoes any variation, it must be due to the action of the given agent.

DETERMINATION OF SPEED OF EXCITATORY IMPULSE IN PLANTS.[2]

As relatively long intervals have to be measured in the determination of velocity, the recorder has its frequency adjusted to ten vibrations per second; hence the space between successive dots represents an interval of one-tenth of a second. In Fig. 8 is given a record for determining the velocity of transmission. The two lower figures give practically identical results of successive

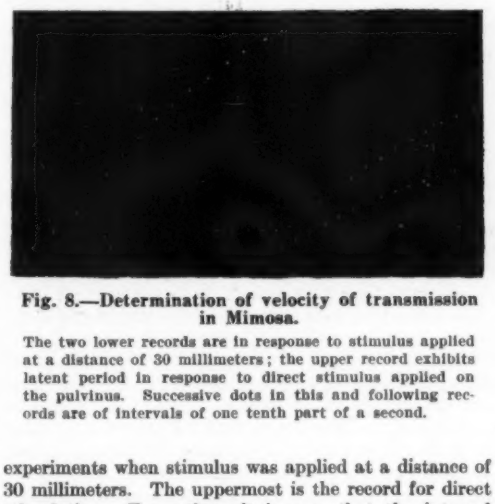


Fig. 8.—Determination of velocity of transmission in Mimosa.

The two lower records are in response to stimulus applied at a distance of 30 millimeters; the upper record exhibits latent period in response to direct stimulus applied on the pulvinus. Successive dots in this and following records are of intervals of one tenth part of a second.

experiments when stimulus was applied at a distance of 30 millimeters. The uppermost is the record for direct stimulation. From these it is seen that the interval between stimulus and response is 1.6 seconds, and that the latent period is 0.1 second. Hence the true time for the excitation to travel through a distance of 30 millimeters is 1.5 seconds, the velocity being 20 millimeters per second.

The velocity of nervous impulse in the plant is slower than those of higher, but quicker than those of lower animals. The speed of the impulse is, however, subject to variation under different conditions. One significant result that came out was that while a plant carefully protected under glass from outside blows looked sleek and flourishing, yet as a complete and perfect organism it proved to be a failure. Its conducting power was found atrophied or paralyzed. But when a succession of blows rained on this effete and bloated specimen, the stimulus canalized its own path of conduction, and it became more alert and responsive, and its nervous impulses became very much quickened.

EFFECT ON PHYSIOLOGICAL AGENCIES ON VELOCITY.

A decisive experiment to discriminate between the theories of mechanical and nervous transmissions consists in the determination of the effect of temperature on the speed of transmission. Temperature has no effect on mechanical propagation, whereas a moderate variation of it profoundly affects the rate of nervous transmission. In the case of the plant, I find that the velocity is doubled by rise of temperature through 9 deg. Cent. When a portion of conducting petiole is subjected to cold the speed of conduction is retarded. Excessive cold temporarily abolishes the conducting power.

As an after-effect of the application of intense cold, the conducting power remains paralyzed for a considerable length of time. It is a very interesting and suggestive fact that I have been able to restore the conducting power quickly by subjecting the paralyzed portion of the plant to a measured and moderate dose of electric shock.

Various physiological blocks can be made to inhibit

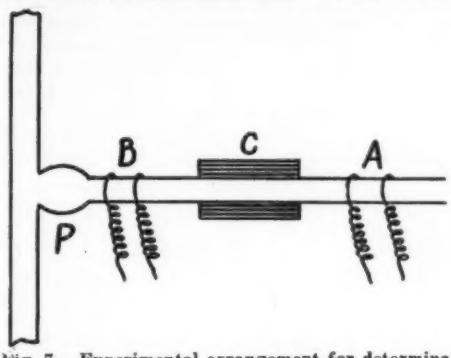


Fig. 7.—Experimental arrangement for determination of velocity of transmission and its variation.

Record is first taken when stimulus is applied near the pulvinus at *B* (latent period) and that at a distant point on the leaf stalk at *A*. Difference of two gives time for transmission from *A* to *B*. The band of cloth, *C*, is for local application of warmth, cold, anesthetics, and poisons.

the excitatory impulse in the plant, precisely as in the case of animal nerve. The nervous impulse in plants may thus be arrested by electrotonic block or by the action of poisons. By applying solution of potassium cyanide I have been able to abolish the conducting power in the plant in a time as short as five minutes. This investigation on the simplest type of plant-nerve is expected to cast a flood of light on the very obscure phenomenon of nervous impulse in general, and the causes operative in bringing about the degeneration of the normal function of the nerve.

SPONTANEOUS PULSATION.

In certain animal tissues, a very curious phenomenon is observed. In man and other animals, there are tissues which beat, as we say, spontaneously. So long as life lasts, so long does the heart continue to pulsate. There is no effect without a cause. How then was it that these pulsations became spontaneous? To this query, no fully satisfactory answer has been forthcoming. We find, however, that similar spontaneous movements are also observable in plant tissues, as in *D. gyrans*, or the telegraph plant, the leaflets of which dance up and down. The characteristics of the automatic pulsations in the plant could not be determined on account of the apparent impossibility of obtaining a record. The leaflets are too minute and the pull exerted too feeble to overcome friction of the recording surface. This difficulty has been obviated by the device of my oscillating recorder (see pulse-record, Fig. 9). From the records thus obtained, I am enabled to say that the automatic movements of both plants and animals are guided by laws which are identical. Thus I find, as with the pulsating heart, so also with the pulsating leaflet, the rhythmic frequency is increased under the action of warmth, and lessened under cold, increased frequency being attended by diminution of amplitude, and *vice versa*. Under ether, there is a temporary arrest, revival being possible when the vapor is blown off (Fig. 10). More fatal is the effect of chloroform. The most extraordinary parallelism, however, lies in the fact that those poisons which arrest the beat of the heart in a particular way, arrest the plant-pulsation also in a corresponding manner, the arrest produced being either at systole or diastole, depending on the characteristic reaction of the poison. Taking advantage of the antagonistic reactions of specific poisons, I have been able to revive a poisoned leaflet by the application of another counteracting poison.

INSTANTANEOUS RECORD OF GROWTH.

As a further example of automatic activity we may take the phenomenon of growth. The rate of growth is so extremely slow that even the proverbial pace of the snail is two thousand times quicker! It would take an average plant two hundred years to cover the short distance of a mile. This extreme slowness is a serious drawback in the investigation on growth. For even with the existing magnifying growth-recorders it would take

Fig. 10.—Arrest of pulsation of Desmodium under ether.

The arrow indicates the time of application.

[2] For a more detailed account, consult:
Bose: "An Automatic Method for the Investigation of Velocity of Transmission of Excitation in Mimosa." Phil. Trans. Royal Society, Series B, vol. cciv.
Bose: "Plant Response." (Longmans, Green, 1906.)
Bose: "Researches on Irritability of Plants." (Longmans, Green, 1913.)

many hours for the variation of growth to be recorded under a changed condition in the environment. The results thus obtained are subject to errors brought about by the variation of growth which takes place spontaneously in the course of a few hours. Growth can be assumed to remain constant only for a short time; on this account it is necessary to conclude an experiment in the course of a few minutes.

The difficulties have been overcome in my high magnification crescograph, which records the absolute rate of growth in a time so short as the single beat of the pendulum. The various magnifications available are a thousand or ten thousand times. For demonstration purposes, I have been able to secure a magnification of a million times. The infinitesimal growth thus becomes magnified so as to appear rushing forward as if in a race. The actual rate of growth and its variations under the action of drugs, of food-materials, of various electrical and other forms of stimuli, are thus recorded in the course of a few minutes. The great importance of this method of investigation in agriculture is sufficiently obvious.

THE PLANT'S RESPONSE TO THE SHOCK OF DEATH.

A time comes when, after an answer to a supreme shock, there is a sudden end of the plant's power to give any further response. This supreme shock is the shock of death. Even in this crisis there is no immediate change in the placid appearance of the plant. Drooping and withering are events that occur long after death itself. How does the plant, then, give this last answer? In man, at the critical moment, a spasm passes through the whole body, and similarly in the plant I find that a great contractile spasm takes place. This is accompanied by an electrical spasm also. In the script of the death-recorder the line, that up to this point was being drawn, becomes suddenly reversed and then ends. This is the last answer of the plant to man's research.

The plant has thus been made to exhibit many of the activities which we have been accustomed to associate only with animal life. In one case, as in the other, stimulus of any kind will induce a responsive thrill. There are rhythmic tissues in the plant which, like those in the animal, go on throbbing ceaselessly. These spontaneous pulsations in one case, as in the other, are affected by various drugs in an identical manner. And in one case, as in the other, the tremor of excitation is transmitted with a definite and measured speed from point to point along conducting channels. The establishment of this similarity of responsive actions in the plant and animal will be found of the highest significance; for we now realize that it is by the study of the simpler phenomena of irritability in the vegetal organisms that we may expect to elucidate the more complex physiological reactions of the animal.

The Stability of Aeroplanes*

The Various Intricate Problems of Balance

By Orville Wright, B.S., LL.D.

A FLYING machine must be balanced in three directions: about an axis fore and aft in its line of motion, about an axis extending in a lateral direction from tip to tip of the wings, and about a vertical axis. The balance about the lateral axis is referred to as fore-and-aft or longitudinal equilibrium; that about the fore-and-aft axis as lateral equilibrium, and that about the vertical axis is generally referred to as steering, although its most important function is that of lateral equilibrium.

If the center of support of an aeroplane surface would remain fixed at one point, as is practically the case in marine vessels and in balloons and airships, equilibrium would be a simple matter. But the location of the center of pressure on an aeroplane surface changes with every change in the angle at which the air strikes the surface. At an angle of 90 degrees it is located approximately at the center of the surface. As the angle becomes less, the center of pressure moves forward. On plane surfaces it continues to move forward as the angle decreases until it finally reaches the front edge. But on cambered surfaces the movement is not continuous. After a certain critical angle of incidence is reached, which angle depends upon the particular form of the surface, the center of pressure moves backward with further decrease in angle until it arrives very close to the rear edge. At angles ordinarily used in flying, angles of 3 degrees to 12 degrees, the travel of the center of pressure is in this retrograde movement and is located, according to the angle of incidence, at points between 30 per cent and 50 per cent back of the front edge of the surface. The location of the center of pressure on any given surface is definitely fixed by the angle of incidence at which the surface is exposed to the air.

The placing of the center of gravity of the machine below its center of support appears, at first glance, to be a solution of the problem of equilibrium. This is the method used in maintaining equilibrium in marine vessels and in balloons and airships, but in flying machines it has the opposite of the desired effect. If a flying machine consisting of a supporting surface, without elevator or other means of balancing, were descending vertically as a parachute, the center of gravity vertically beneath the center of support would maintain its equilibrium. But as soon as the machine begins to move forward the center of pressure, instead of remaining at the center of the surfaces, as was the case when descending vertically, moves toward that edge of the surface which is in advance. The center of gravity being located at the center of the surface and the center of pressure in advance of the center of the surface, a turning moment is created which tends to lift the front of the machine, thus exposing the surfaces at a larger angle of incidence and at the same time to a greater resistance to forward movement. The momentum of the machine, acting through its center of gravity below the center of forward resistance, combines with the forward center of pressure in causing the surface to be rotated about its lateral axis. The machine will take an upward course until it finally comes to a standstill. The rear edge of the surface will now be below that of the front edge and the machine will begin to slide backward. The center of pressure immediately reverses and travels toward the rear edge of the surface, which now in the backward movement has become the front edge. The center of gravity again being back of the center of pressure, the advancing edge of the surface will be lifted as before, and the pendulum effect of the low weight will be repeated. A flying machine with a low center of gravity, without rudders or other means to maintain its equilibrium, will oscillate back and forth in this manner until it finally falls to the ground.

It will have been observed from the foregoing that the equilibrium in the horizontal plane was disturbed by two turning moments acting about the lateral horizontal axis of the machine; one produced by the force of gravity and the lift of the surface acting in different vertical lines, and the other by the center of momentum and the center of resistance acting in different horizontal lines.

It is evident that a low center of gravity is a disturbing instead of a correcting agent. The ideal form of flying machine would be one in which the center of gravity lies in the line of the center of resistance to forward movement and in the line of thrust. In practice this is not always feasible. Flying machines must be built to land safely as well as to fly. A high center of gravity tends to cause a machine to roll over in landing. A compromise is therefore adopted. The center of gravity is kept high enough to be but a slight disturbing factor in flight and at the same time not so high as to interfere in making safe landings.

The three forces acting on an aeroplane in the direction of its line of motion are the thrust of the propellers, the momentum or inertia of its weight, and the resistance of the machine to forward travel. If traveling in any other than a horizontal course, a component of gravity in the line of motion will have to be reckoned with. When these forces are exerted in the same line, with the centers of thrust and momentum acting in the opposite direction to that of the center of resistance, a variation in the quantity of any one, or of all, of these forces will not in itself have a disturbing effect on the equilibrium about the lateral horizontal axis. But these forces in the ordinary flying machine do not act in the same line. Usually the center of thrust is high in order to give proper clearance between the propellers and the ground; the center of gravity is low to enable the machine to land without danger of being overturned; and the center of resistance is usually between the centers of thrust and gravity. When a flying machine is traveling at uniform speed the propelling forces exactly equal the resisting forces. In case the thrust of the propellers is diminished by throttling the motor, the momentum of the machine acting below the center of resistance carries the lower part of the machine along faster than the upper part, and the surfaces thus will be turned upward, producing a greater angle and a greater resistance. The same effect is produced if the machine be suddenly struck by a gust of wind of higher velocity from in front. The thrust of its propellers will be temporarily slightly decreased, the resistance due to the greater wind pressure will be increased, and the momentum of the machine (the center of gravity being low) will in this case also turn the surfaces upward to a larger angle. While these variations in the forces acting in the horizontal line have of themselves a certain amount of disturbing effect, yet it is from the changes of incidence which they introduce that one encounters the greatest difficulty in maintaining equilibrium.

The two principal methods used in preserving fore-and-aft equilibrium have been, first, the shifting of weight so as to keep the center of gravity in line with the changing center of lift; and, second, the utilization of auxiliary surfaces, known as elevators, to preserve the position of the center of pressure in line with a fixed center of gravity. The first method has been found impracticable on account of the impossibility of shifting large weights quickly enough. The second method is that used in most of the flying machines of to-day.

Flying machines of this latter type should have their auxiliary surfaces located as far as possible from the main bearing planes, because the greater the distance the greater is the leverage and consequently the smaller the amount of surface required. The auxiliary surfaces are usually placed either in front or in the rear of the main supporting surfaces, since they act with greater efficiency in these positions than when placed above or below.

With a view to high efficiency, no part of either the main surfaces or the auxiliary surfaces should be exposed on their upper sides in a way to create downward pressures. One pound of air pressure exerted downward costs as much in propelling power as two pounds of downward pressure produced by actual weight carried. This is due to the fact that the total pressure on an aeroplane is not vertical, but approximately normal to the plane of the surface. This pressure may be resolved into two forces, one acting in a line parallel with the direction of travel, and the other at right angles to the line of travel. One is termed "lift" and the other "drift." With a given aeroplane surface, the drift and lift for any given angle of incidence always bear a definite ratio to one another. This ratio varies from 1 to 12 to 1 to 1, according to the angle of incidence and the shape of the surface. On an average it is about 1 to 6, so that the thrust required of the propeller in the ordinary flying machine is approximately one sixth of the weight carried. When traveling on a horizontal course the lift is vertical and is exactly equal to the total weight of the machine and load. This load may be real weight, or it may be partly real weight and partly downward pressures exerted on parts of the surfaces. For every pound of weight carried, a thrust of approximately one sixth pound is required. If, however, instead of real weight a downward air pressure is exerted on some part of the machine, this downward pressure must be overcome by an equal upward pressure on some other part of the machine, to prevent the machine from descending. In this case the horizontal component of the one pound downward pressure will be about one sixth pound, and the horizontal component of the compensating upward pressure also will be about one sixth pound, making a total of one third pound required in thrust from the propellers, as compared with one sixth pound thrust required by one pound actual weight carried. It is, therefore, evident that the use of downward air pressures in maintaining equilibrium is exceedingly wasteful, and, as far as possible, should be avoided. In other words, when the equilibrium of an aeroplane has been disturbed, instead of using a downward air pressure to depress the elevated side an upward pressure should be utilized to elevate the low side. The cost in power is twice as great in one case as in the other.

The dynamically less efficient system of downward air pressures is used to some extent, however, on account of its adaptability in producing more or less inherently stable aeroplanes. An inherently stable aeroplane may be described as one in which equilibrium is maintained by an arrangement of surfaces, so that when a current of air strikes one part of the machine

* Abstract of a paper presented at a stated meeting of the Franklin Institute held Wednesday, May 20th, 1914, when Dr. Wright received the Institute's Elliott Cresson Medal in recognition of the epoch-making work accomplished by him in establishing on a practical basis the science and art of aviation.

creating a pressure that would tend to disturb the equilibrium, the same current striking another part creates a balancing pressure in the opposite direction. This compensating or correcting pressure is secured without the mechanical movement of any part of the machine.

The first to propose the use of this system for the fore-and-aft control of aeroplanes was Penaud, a young French student, who did much experimenting with model aeroplanes in the 70's of the last century. His system is used only to a slight extent in the motor-driven aeroplanes of to-day, on account of its wastefulness of power and on account of its restriction of the maneuvering qualities of the machine.

Penaud's system consists of a main bearing surface and a horizontal auxiliary surface in the rear fixed at a negative angle in relation to the main surface. The center of gravity is placed in front of the center of the main surface. This produces a tendency to incline the machine downward in front, and to cause it to descend. In descending the aeroplane gains speed. The fixed surface in the rear, set at a negative angle, receives an increased pressure on its upper side as the speed increases. This downward pressure causes the rear of the machine to be depressed till the machine takes an upward course. The speed is lost in the upward course, the downward pressure on the tail is relieved, and the forward center of gravity turns the course again downward. While the inherently stable system will control a machine to some extent, it depends so much on variation in course and speed as to render it inadequate to meet fully the demands of a practical flying machine.

In order to secure greater dynamic efficiency and greater maneuvering ability, auxiliary surfaces mechanically operable are used in present flying machines instead of the practically fixed surfaces of the inherently stable type. These machines possess the means of quickly recovering balance without changing the direction of travel and of maneuvering with greater dexterity when required. On the other hand, they depend to a greater extent upon the skill of the operator in keeping the equilibrium. It may be taken as a rule that the greater the dynamic efficiency of the machine and the greater its possibilities in maneuvering, the greater the knowledge and skill required of the operator.

If the operator of a flying machine were able to "feel" exactly the angle at which his aeroplane meets the air, 90 per cent at least of all aeroplane accidents would be eliminated. It has been the lack of this ability that has resulted in so large a toll of human lives. Instruments have been produced which indicate closely the angle of incidence at which the machine is flying, but they are not in general use. Nor does the average flyer realize how exceedingly dangerous it is to be ignorant of this angle. Most of the flyers are aware that "stalling" is dangerous, but do not know when they really are "stalling."

A flying machine is in great danger when it is flying at its angle of maximum lift. A change either to a smaller or a larger angle results in a lesser lift. There is this important difference however, whether the angle be increased or decreased. While a smaller angle gives less lift, it also has less drift resistance, so that the machine is permitted to gain speed. On the other hand, the larger angle gives not only less lift but encounters a greater resistance, which causes the speed of the machine to be rapidly checked, so that there is a double loss of lift—that due to angle and that due to a lesser speed.

The maximum lift is obtained in most flying machines at some angle between 15 degrees and 20 degrees. If the machine be gliding from a height with the power of the motor throttled or entirely turned off, and the operator attempt to turn it to a level course, the speed of the machine will soon be reduced to the lowest at which it can support its load. If now this level course be held for even only a second or two, the speed and the lift will be so diminished that the machine will begin to fall rapidly.

The center of pressure on a cambered aeroplane surface at angles greater than 12 degrees to 15 degrees travels backward with increase of angle of incidence, so that when a machine approaches the "stalled" angles the main bearing surfaces are generally carrying practically all of the weight and the elevator practically none at all. Under these conditions the main surfaces fall more rapidly than does the rear elevator. The machine noses downward and plunges at an exceedingly steep angle toward the earth. This plunge would tend to bring the machine back to normal speed quickly were the machine flying at its usual angle of incidence. But at the large angles of incidence the drift is a large part of the total pressure on the surfaces, so that, although plunging steeply downward, speed is recovered but slowly. The more the operator tries to check the downward plunge by turning the elevator, the greater becomes the angle of incidence, and the greater the forward resistance. At ordinary stalled angles the machine must descend at an angle of about 25 degrees with reference to the horizontal in order to maintain its speed. If the speed be already below that necessary for support, a steeper angle of descent will be required, and considerable time may be consumed before supporting speed can be recovered. During all this time the machine is plunging downward. If the plunge begins at a height of less than two or three hundred feet, the machine is likely to strike the ground before the speed necessary to recover control is acquired.

The danger from "stalling" comes in the operator attempting to check the machine's downward plunge by turning the main bearing surfaces to still larger angles of incidence instead of pointing the machine downward, at a smaller angle of incidence, so that the speed can be recovered more quickly. It is safe to say that fully 90 per cent of the fatal accidents in flying are due to this cause. Most of the serious ones occur when, after long glides from considerable heights, with the power of the motor reduced, an attempt is made to bring the machine to a more level course several hundred feet in the air. The machine quickly loses its speed and becomes "stalled." All of us who have seen the novice make a "pancake" landing have seen the beginning of a case of "stalling" which might have been fatal had it taken place at a height of one or two hundred feet.

The greatest danger in flying comes from misjudging the angle of incidence. If a uniform angle of incidence were maintained, there would be no difficulty in fore-and-aft equilibrium. As has already been stated, for any given surface and any given angle of incidence the position of the center of pressure is fixed. Under these conditions, if the center of gravity were located to coincide with the center of pressure and a uniform angle of incidence maintained, the machine would always be in equilibrium.

It is in accordance with this principle that experiments the past year have brought about a considerable advance in the development of automatic stability. A small horizontal wind vane is so mounted on the machine as to ride edgewise to the wind when the machine is flying at the desired angle of incidence. In case the machine varies from the desired angle, the air will strike the vane on either its upper or lower side. The slightest movement of the vane in either direction brings into action a powerful mechanism for operating the controlling surfaces.

If the wind strikes the vane on the under side, as would be the case when the machine takes a larger angle of incidence, the elevator is turned to cause the machine to point downward in front till the normal angle is restored. If the air strike the vane from above, a smaller angle of incidence is indicated, and an opposite action on the elevator is produced. In this system no particular angle of the machine with the horizontal is maintained. It is the angle at which the air strikes the aeroplane surface that is important. If the vane is set at an angle of 5 degrees with the main supporting surfaces, and the machine is traveling on a level course, increasing the power of the motor will cause it to begin taking on more speed. But as the lifting effect of an aeroplane surface is the product of two factors—its speed and its angle of incidence—any increase in speed will produce a greater lift and cause the machine to rise. The machine will now be turned upward, with the surfaces meeting the air at an angle of 5 degrees. On the contrary, if the power of the motor be reduced or entirely turned off, the machine will immediately begin to decrease in speed, requiring a larger angle of incidence for support. But as soon as the angle begins to increase the air will strike the regulating vane on the underside and the elevator will be turned, pointing the machine downward till the component of gravity in the direction of travel becomes sufficient to maintain the normal speed. In this case the planes will be inclined downward with reference to the horizontal. It is evident that a machine controlled by regulating the angle of the machine with reference to the impinging air is not liable to the dangers of "stalling" already described.

Several other methods of maintaining fore-and-aft equilibrium automatically have been proposed. One utilizes the force of gravity acting on a pendulum or a tube of mercury; the other, the gyroscopic force of a rapidly revolving wheel. In both of these systems the angle of the machine is regulated with reference to the horizontal, or some other determined plane, instead of with the angle of the impinging air.

In the case just referred to, in which the power of the motor was suddenly turned off while traveling on a level course, with these systems, the planes would be maintained at their original angle with the horizontal without any regard to the angle of incidence. The machine would continue forward till, through the loss of momentum, its speed would become so reduced and its angle of incidence so great that it would be exposed to the dangers of diving.

The pendulum and mercury tube have other serious faults which render them useless for regulating fore-and-aft equilibrium. If the machine suddenly meet with a greater resistance to forward travel, either as a result of change in direction or of meeting a stronger gust of wind from in front, and its speed be ever so slightly checked, the pendulum will swing forward and instead of turning the machine downward, so as to maintain the normal speed, will cause the machine to be inclined upward in front and thus further increase its forward resistance.

The pendulum has proved itself an exceedingly useful device, however, in regulating the lateral stability of aeroplanes. In this case the effects of momentum and centrifugal force act on the pendulum in the proper direction to produce desired results.

I believe the day is near at hand when the flyer will be almost entirely relieved of the work of maintaining the equilibrium of his machine, and that his attention will be required only to keeping it on its proper course and in bringing it safely in contact with the ground when landing.

Problems Involved in the Cracking of Oils*

By Walter F. Rittman

UNTIL recently it has been common to consider the so-called tar and petroleum oils as two separate and distinct materials. The present conceptions of organic chemistry however, avoid any sharp differentiations, such as those between the methane and benzine series. Instead, all hydrocarbons are considered together, and indicated as differing only in their hydrogen content. The latter classification is more fortunate because in the course of a dozen petroleums from different fields nearly all the various hydrocarbon series are represented. Many petroleums contain considerable percentages of the same constituents that are found in oil or water gas tar. In fact, it is possible to find two petroleums which differ as much in comparison as certain petroleums differ from so-called tar.

In dealing with the technical use of petroleum it can be said that we already know something about its end products; it at least appears that we know more about the end products than we do about the application of the most favorable conditions for obtaining maximum yields of the desired end products. It is known that valuable gasoline and illuminating gas can be obtained by cracking petroleum. What we want to know is how to increase the yields of gasoline or illuminating gas from a given amount of oil. It is questionable how much increase can be obtained by the perfection of the well known methods now in use. Radical increases can result only from the application of radical scientific principles.

In the production of petroleum end products practically all the variables of chemical reactions are involved. While this fact complicates the problem it makes the field of research more fertile and greatly enlarges its possibilities. We are dealing with chemistry involving both liquids and gases and with all the physical and chemical principles which apply to both of them. Mechanism of reaction, duration of temperature, contact surface, catalysis, temperature, pressure, and concentration conditions are all vitally important in the cracking of oils. They are all interesting, but in the time allotted me I shall deal with only the last three: temperature, pressure, and concentration.

The information that endothermic reactions work better at high temperatures while exothermic reactions work better at low temperatures is important, but this information does not become fully valuable until we regard as well the chemical equilibria between the various reacting constituents. The subject of chemical equilibrium is studied by practically all undergraduates, but its application to industrial problems, despite its value wherever applied, is still limited. There are very few experimental data dealing with equilibria between hydrocarbon vapors and gases; the principles affecting equilibria in fields which do not involve hydrocarbons are well known, however. There is no reason why these same principles should not be applied directly to hydrocarbons. Doing so leads to theoretical conclusions which suggest experimental research. Application of the principles indicates that the entire problem of cracking oils revolves about the equilibrium or kinetic conception of reaction.

It has been experimentally determined that when hydrogen iodide (HI) is heated there is a definite percentage of decomposition to H_2 and I_2, dependent upon the temperature of the system. Only at extremes of temperature do the equilibrium conditions carry the reaction completely in one direction. As the temperature is increased the percentage of decomposition increases. Equilibrium conditions prevail when the square of the partial pressure of HI, divided by the product of the partial pressures of H_2 and I_2, equals a constant.

The equilibrium relationships for hydrocarbons reac-

* *Journal* of the Society of Chemical Industry.

tions have not been determined, but because of the validity of the equilibrium principles and the reversible nature of all chemical reactions investigated, we are reasonably safe in applying the same principles and reasonings to hydrocarbon reactions. The equilibrium considerations are important whatever end it is desired to reach, whether illuminating gas, gasoline, or some other products are the ones being sought. In some cases it will be found desirable to permit the reaction to reach an equilibrium at a relatively high temperature, whereas in other equally important hydrocarbon reactions the equilibrium of this high temperature would be destructive. In either case the equilibrium equation would serve as an indication of the degree of success that might be expected, as well as of the direction the reaction would take. Unfortunately practically none of the numerical values of the equilibrium constants for hydrocarbon reactions have been experimentally determined.

The application of thermodynamic equilibria to hydrocarbons can be illustrated by one or two simple examples. Let us consider the following reactions and their constants (which are approximate):

	K_{600}	K_{800}
$C_2H_6 \rightleftarrows C_2H_4 + 2H$	0.0027	1.28
$3C_2H_2 \rightleftarrows C_6H_6$	9×10^{22}	1.2×10^{17}
$2CH_4 \rightleftarrows C_2H_4 + 2H_2$	0.0000001	0.0004

Any number of others might be taken. Important mathematical expressions which give approximations for the values of these equilibrium constants for hydrocarbons can be found in such works on thermodynamics and physical chemistry.[1] As soon as more of them are known we shall have a better understanding of temperature conditions as related to other conditions in oil-cracking processes.

The application of different pressures in the sphere of reaction of the cracking process has been limited. Numerous patents and articles can be found indicating the use of increased pressure in the production of gasoline and illuminating gas. It has long been known that lubricating oils can be recovered more efficiently by distillation under partical vacuum. The distillation of aniline under diminished pressure through the use of steam is common laboratory practice. In such cases, however, the object of the process is not to crack an oil, but to avoid cracking it. So far, the effect of greatly diminished pressure on oil-cracking processes is practically uncovered. For a detailed consideration of this aspect of oil cracking see the articles on "Thermal Reactions in Carbureting Water Gas," by Whitaker and Rittman, *Jour. Ind. and Eng. Chem.*, vol. 6, pp. 383 and 472. To show the effect of varying the pressure when cracking an oil, consider the general reaction, $A \rightleftarrows 2B$ where equilibrium exists when $KA = B^2$. This equilibrium constant is identical with the ones referred to under temperature, and deals with the relative partial pressures at equilibrium under differing conditions of pressure. For numerical illustration assume the value of K to be equal to 1. From this one finds for partial pressures, when $A = 100$, $B = 10$, or when $A = 0.01$, $B = 0.1$. In the first case the partial pressure of A is ten times as great as that of B; in the second case the partial pressure of A is only one tenth as large as the partial pressure of B. In other words, by simply changing the total pressure on the system and keeping all other conditions constant, the ratio of A to B for the pressures shown has been divided by 100. This change can also be observed by plotting the parabola, $B^2 = KA$, where A and B are variables. From this it becomes evident that diminished pressure increases dissociation or decomposition to the gaseous state, whereas increased pressure decreases dissociation. The manufacture of gas under diminished pressure, as reported in the above mentioned articles, illustrates the former; the present methods of manufacturing gasoline from heavy oils by heating them under increased pressure illustrates the latter.

In dealing with the influence of concentration changes we are applying one of the common laws of physical chemistry. In the dissociation of HI by heat according to equation $2HI \rightleftarrows H_2 + I_2$, $K = \frac{P_{H_2} P_{I_2}}{P_{HI}^2}$ it is a well-known fact that less of the HI will dissociate in an atmosphere of H_2 or I_2, than in an atmosphere of nitrogen or any other inert gas. This can be observed from a mathematical consideration of equilibrium conditions, purely aside from the chemistry involved. Since the value of K does not change at any given temperature, if the partial pressure of H_2 is increased, the partial pressure of I_2 necessarily decreases unless the partial pressure of HI is increased simultaneously. Assume that the H_2 of the example cited were in excess to the extent that 50 per cent, instead of 10 per cent, of the resultant mixture were hydrogen; what, in this case, would be the partial pressures of HI and I_2, assuming the total pressure to be equal to 1 atmosphere? 0.5 = partial pressure H_2, x = partial pressure HI, 0.5 − x = partial pressure I_2.

$$K = \frac{P_{H_2} P_{I_2}}{P_{HI}^2} \qquad 0.0156 = \frac{(0.5)\ (0.5 - X)}{X^2}$$

Solving $X = 0.492$ HI, $0.5 - X = 0.008$ I_2, 0.5 H_2. 49.2 per cent HI, 0.8 per cent I_2, 50 per cent H_2. Thus, by having a large excess of hydrogen it is possible to eliminate, practically, the uncombined iodine. Or looking at the problem in another way, it is observed that almost none of the HI is dissociated, because of the excess of one of the end products of decomposition. In cracking oil hydrogen and methane are always among the end products.

Drawing an analogy one would expect that cracking petroleum in the presence of an end product, such as hydrogen, would lessen oil decomposition; in ordinary practice some oil decomposition is necessary to produce the hydrogen and other gases required by the equilibrium at that temperature. This decomposition might be avoided by the addition of the necessary hydrogen or other gases fram an outside source. In experiments carried out in the laboratory it was found that when oil is cracked in the presence of an excess of hydrogen, not only does none of the hydrogen of the oil split off, but a considerable part of the added hydrogen actually enters into combination. This means that it is not necessary to generate new gaseous end products at the expense of more valuable hydrocarbons.

In conclusion, it appears that through the application of physical chemical principles to the cracking of oil, a better control of and greater flexibility in the resultant end products can be expected.

[1] Nernst, Theoretical Chemistry (seventh edition). Jellinek Physikalische Chemie der Gasreaktionen Sakur Thermochemie und Thermodynamik. Morgan, the Elements of Physical Chemistry.

Gun Deafness and Its Prevention

A SUBJECT of timely interest and importance and one that is closely allied to the subject of the industrial diseases in general is that of the injuries to the ear resulting from loud concussions. What may be regarded as one of the minor accidents of war is nevertheless, because of the large number of individuals concerned at the present time, one that cannot be ignored. Moreover, the aural injuries to which the soldier is exposed are no different from those of the boilermaker, of the structural iron worker, of the sportsman, and of those who are exposed to the shriek of the railway whistle when a train is passing through a tunnel or covered station. Jobson Horne, in the *Lancet*, August 15th, 1914, points out that the report of a piece of artillery, the concussion of an explosion, or the firing of a cannon close to the ear may exert its injurious effects upon the nerve terminals of the ear, may cause rupture of the drum membrane, and may even result in irremediable deafness. During the Russo-Japanese war, among the 1,791 men who were wounded in the naval engagements there were 116 cases of concussion of the labyrinth and rupture and congestion of the tympanic membrane, which cases represented 7 per cent of the wounded who survived. The injuries to the drum and to the nerve endings are due to the sudden condensation or rarefaction of the air in the external auditory meatus. As a rule one ear is more affected than the other. Politzer states that with the improvements in modern artillery ruptures of the drum membrane are now scarcely ever met with. This is attributed to the introduction of breech loaders and also to the fact that the serving party withdraws to a distance of about twelve paces with the exception of one man who attends to the firing, but who also stands at a considerable distance.

In naval warfare, however, the gunners cannot be protected in this manner. Experience has taught the gunner that by keeping the mouth open so as to equalize the air pressure on each side of the drum membrane the unpleasant consequences of concussion may be diminished. The toothpick that is chewed by naval officers while serving the guns partly fulfills this requirement, although a piece of rubber rolled between the teeth would be still better as a means of keeping the mouth partly open. The Japanese naval surgeons distributed pledgets of absorbent cotton to the entire crew with the instruction that the ears be plugged up during the firing of guns. In spite of this measure, possibly on account of its careless application in individual cases, many instances of deafness resulted. In 1911 the British Admiralty advised the use of an aural plug consisting of a mixture of plasticine and cotton-wool. Jobson Horne believes that an efficient aural plug should be close-fitting and impervious, and while reducing the intensity of sound should not prevent hearing; it should be easy to insert and easy to remove intact; it should be non-irritating; it should be inexpensive so that the same plug may not be used repeatedly; and, above all, it must be as nearly antiseptic as possible. Cotton-wool when inserted sufficiently tightly is not easily removed intact and does not long remain sterile when handled by men engaged in gun-firing. The ear plugs made of vulcanite rubber, or celluloid cannot b supplied to fit exactly the channel of the ear. They m be made of a substance that retains its shape with hardening or softening and remains ever plastic. A sub stance having the consistency of jeweler's wax may b produced and may be made to fulfill all the requirement of effectively plugging the ears and at the same time preventing infection.—*Medical Record.*

A Novel Method of Fighting Spotted Fever is t be undertaken experimentally in the Bitterroot Na tional Forest, Montana, by the Forest Service and the Public Health Service, in co-operation with local sheep growers. Spotted fever is believed to be disseminated by a species of tick, and the engorging of the female tick with blood is one of the essential features of re production. The host on which this engorging take place is necessarily one of the larger mammals, and the commonest hosts appear to be domestic animals. As the spotted fever tick is so abundant in the Bitter root Forest as to constitute a serious menace to man and beast, it is proposed to turn loose a flock of 2,50 sheep to graze in the forest, in the expectation that a great number of ticks will attach themselves to these animals. Then, from time to time, the sheep will be freed of ticks by dipping them in an insecticide solution. It is hoped that by this means ticks may be gradually banished from the forest.

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Table of Contents

PAGE
Heredity.—III.—By Prof. William Bateson . . . 19
Why Hens Stop Laying in Winter . . . 19
The Cyclopean Mystery of Abydos.—By Edouard Naville.—5 illustrations . . . 19
Mines in Naval Warfare . . . 19
The Impurities of Coal Gas . . . 19
The Magnolia Cut-off.—By Harry C. Plummer.—Illustrated . . . 19
The Baltic and Black Sea Canal Scheme . . . 20
European Railways in War Time . . . 20
Plant Autographs and Their Revelations.—10 illustrations . . . 20
The Stability of Aeroplanes.—By Orville Wright, B.S., LL.D. . . . 20
Problems Involved in the Cracking of Oils.—By Walter F. Rittman . . . 20
Gun Deafness and Its Prevention . . . 20